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National Survey of Pesticides in Drinking Water Wells
Phase 1 Report

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Phase I Report

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The U.S. Environmental Protection Agency (EPA) has completed its five-year National Survey of Pesticides in Drinking Water Wells (the Survey or NPS). The Survey is the first and perhaps the most extensive monitoring survey ever undertaken to evaluate the presence of pesticides, pesticide degradates, and nitrate in drinking water wells in the United States. EPA's Phase I Report provides national estimates of the occurrence and frequency of detections of nitrate and pesticides in drinking water wells. The Phase I results of the Survey indicate that at least half of the nation's drinking water wells contain detectable amounts of nitrate, with a small percentage of concentrations higher than EPA's regulatory and health-based limits for drinking water (about 1.2% of community water system (CWS) wells and about 2.4% of rural domestic wells).

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- County Agricultural Extension Agents throughout the country
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- National Association of Counties (NACO)
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Executive Summary

The U.S. Environmental Protection Agency (EPA) has completed its five-year National Survey of Pesticides in Drinking Water Wells (the Survey or NPS). The Survey is the first and perhaps the most extensive monitoring survey ever undertaken to evaluate the presence of pesticides, pesticide degradates, and nitrate in drinking water wells in the United States. EPA's Phase I Report provides national estimates of the occurrence and frequency of detections of nitrate and pesticides in drinking water wells. The Phase I results of the Survey indicate that at least half of the nation's drinking water wells contain detectable amounts of nitrate, with a small percentage at concentrations higher than EPA's regulatory and health-based limits for drinking water (about 1.2% of community water system (CWS) wells and about 2.4% of rural domestic wells).

Based on the results of the Survey, EPA estimates that about 52.1% of the 94,600 community water system wells in the United States contain nitrate; about 10.4% contain one or more pesticides; and about 7.1% may contain both. Of the approximately 10.5 million rural domestic wells, EPA estimates that about 57.0% contain nitrate, 4.2% contain one or more pesticides, and about 3.2% contain both. Exhibit 1 illustrates these proportions. EPA estimates that less than one percent (0.6%) of rural domestic wells containing pesticides, or approximately 60,900 wells, contain at least one pesticide over a Maximum Contaminant Level (MCL) or Lifetime Health Advisory Level (HAL). None of the detections of pesticides or pesticide degradates for CWS wells were above the MCL/HAL. Nevertheless, based on its statistical analysis of the Survey results, EPA estimates that less than 1% (0.8%) of community water system wells contain pesticides at concentrations higher than the MCL or HAL for those chemicals for which an MCL or HAL has been established. These results are illustrated by Exhibit 2.

The pesticides detected most frequently in the Survey were DCPA acid metabolites and atrazine. DCPA acid metabolites are degradates of DCPA, which is used primarily as a weed killer on lawns, turf, and golf courses, and also on a variety of fruits and vegetables. In addition, ten other pesticides were detected at concentrations exceeding the Survey's minimum reporting limits. The concentrations of pesticides and pesticide degradates detected were usually well below levels of health concern.

These Survey results indicate that the *proportion* of wells nationwide found to contain any particular pesticide or pesticide degradate is low. Considering only the proportion of wells containing pesticides over the EPA levels of health concern, Survey results do not demonstrate any immediate widespread health problem. Survey results also show, however, that substantial *numbers* of wells, particularly rural domestic wells, could be affected by the presence of one or more pesticides. In addition, substantial numbers of wells are affected both by the presence of nitrate and by nitrate over EPA levels of health concern. These results indicate that there is need for continued attention to ground-water protection and additional analysis of the issue. A Phase II report, to be released in 1991, will discuss EPA's assessment of the causes and factors associated with the occurrence of pesticides and nitrate in drinking water wells.

Five pesticides – alachlor, atrazine, dibromochloropropane (DBCP), ethylene dibromide (EDB), and gamma-HCH (Lindane) – were detected in rural domestic wells at levels above their respective MCLs/HALs. MCLs are enforceable standards established by EPA pursuant to the Safe Drinking Water Act as the maximum permissible level of a contaminant that is allowed in a public water supply. Although they do not apply as a matter of law to rural domestic wells, MCLs were used as a standard of quality for source drinking water. HALs are the maximum concentration of a contaminant in water that may be consumed safely over an average human lifetime.

Exhibit 1
Estimated Percent of Community Water System Wells and Rural Domestic Wells in the United States with Nitrate and Pesticides

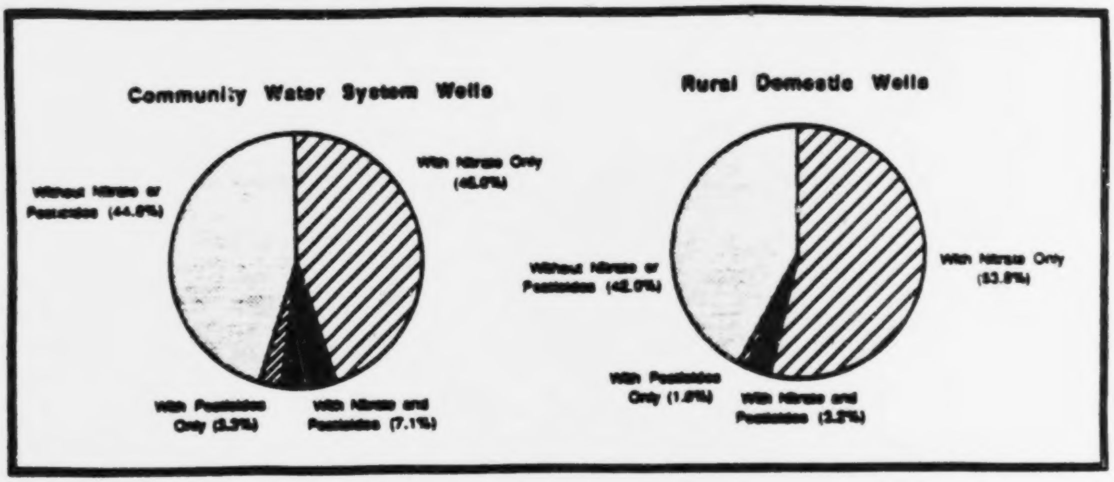
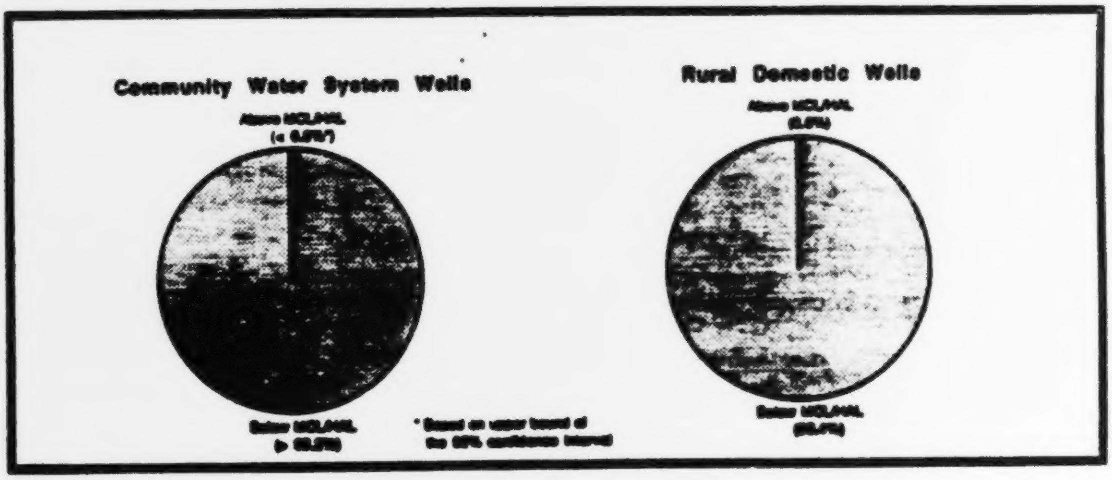


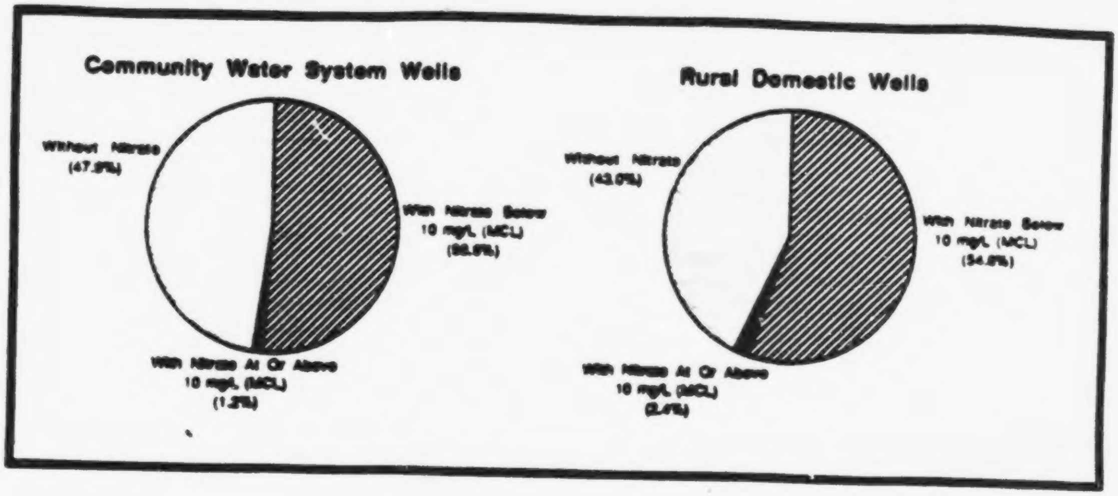
Exhibit 2
Estimated Percent of Community Water System Wells and Rural Domestic Wells in the United States Containing Pesticides Exceeding Health-Based Limits



Relatively small proportions of wells in the United States are estimated to contain nitrate over health-based limits. An estimated 1.2% of community water system wells and an estimated 2.4% of rural domestic wells contain nitrate above the Maximum Contaminant Level of 10 mg/L, as illustrated by Exhibit 3.

Exhibit 3

Estimated Percent of Community Water System Wells and Rural Domestic Wells in the United States Containing Nitrate Exceeding Health-Based Limits



Exhibits 4 and 5 show the estimated number and percent of wells in the United States containing each of the 13 chemicals detected at concentrations above the Survey's minimum reporting limits.

Exhibit 4

Estimated Number and Percent of Community Water System Wells Containing NPS Analytes

Analyte	Estimated Number	95% Confidence Interval (lower - upper)	Estimated Percent	95% Confidence Interval (lower - upper)
Nitrate	49,300	(45,300 - 53,300)	52.1	(50.0 - 56.3)
DCPA acid metabolites	6,010	(3,170 - 8,840)	6.4	(3.4 - 9.3)
Atrazine	1,570	(420 - 2,710)	1.7	(0.5 - 2.9)
Simazine	1,080	(360 - 2,540)	1.1	(0.5 - 2.7)
Prometon	520	(78 - 1,710)	0.6	(0.1 - 1.8)
Hexachlorobenzene	470	(61 - 1,630)	0.5	(0.1 - 1.7)
Dibromochloropropane (DBCP)*	370	(33 - 1,480)	0.4	(0.1 - 1.6)
Dinoseb*	25	(1 - 670)	<0.1	(<0.1 - 0.9)

* Registration cancelled by EPA.

Exhibit 5
Estimated Number and Percent of Rural Domestic Wells Containing NPS Analytes

Analyte	Estimated Number	95% Confidence Interval (lower - upper)	Estimated Percent	95% Confidence Interval (lower - upper)
Nitrate	5,990,000	(5,280,000 - 6,700,000)	57.0	(50.3 - 63.6)
DCPA acid metabolites	264,000	(129,000 - 477,000)	2.5	(1.2 - 4.5)
Atrazine	70,800	(13,300 - 214,000)	0.7	(0.1 - 2.0)
Dibromochloropropane (DBCP)*	38,400	(2,740 - 164,000)	0.4	(<0.1 - 1.6)
Prometon	25,600	(640 - 142,000)	0.2	(<0.1 - 1.4)
Simazine	25,100	(590 - 141,000)	0.2	(<0.1 - 1.3)
Ethylene dibromide*	19,200	(160 - 131,000)	0.2	(<0.1 - 1.2)
gamma-HCH	13,100	(14 - 120,000)	0.1	(<0.1 - 1.1)
Ethylene thiourea	8,470	(1 - 111,000)	0.1	(<0.1 - 1.1)
Bentazon	7,160	(1 - 109,000)	0.1	(<0.1 - 1.0)
Alachlor	3,140	(1 - 101,000)	<0.1	(<0.1 - 1.0)

* Registration cancelled by EPA.

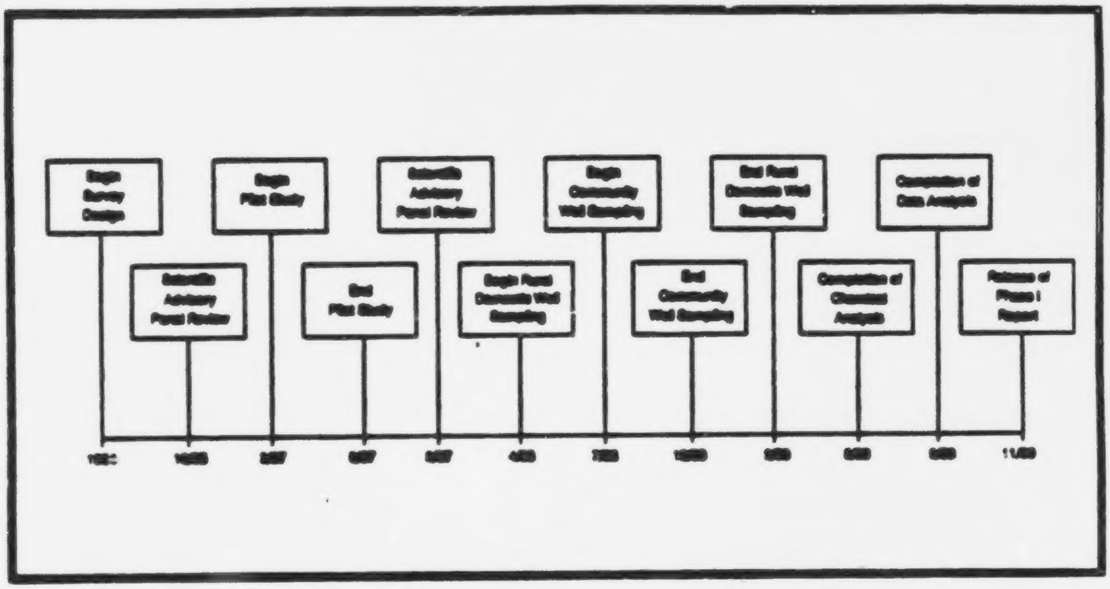
There are significant differences in the uses and possible sources of the most commonly detected Survey analytes. Nitrate and nitrite can occur naturally as well as a result of human activity. (Nitrate and nitrite were not separately distinguished in the Survey laboratory methods and testing, and the results presented reflect both nitrate and nitrite, measured as nitrogen). Nitrate is found in some fertilizers, as well as a result of nitrification of ammonium fertilizers. Nitrate is present in septic systems, animal feed lot wastes, industrial wastewaters, and sanitary landfills. DCPA, a selective herbicide, is the parent compound of DCPA acid metabolites. DCPA is also known by the common names Dacthal and chlorthal dimethyl. It is used to combat certain annual grasses and broadleaf weeds, and is approved for use on turf, ornamentals, and a number of vegetables. Atrazine is used to control many annual broadleaf weeds and certain grasses, and is used primarily on corn and soybeans.

A different number of wells might contain pesticides or nitrate than are indicated by these results. The Survey randomly sampled geographic areas of the country. Local or regional areas with particularly high or low levels of chemicals may not have been chosen for sampling. EPA scheduled the Survey's well sampling activities over a 22 month period to help ensure that water samples were obtained during all seasons and pesticide application cycles. EPA plans to test whether Survey results might be affected by the timing of sampling. The 95% confidence intervals reflect this variability. In addition, the Survey used a stringent series of detection limits and confirmation requirements to ensure a high degree of certainty about the detections that were reported. Additional chemicals might have been present in the wells sampled, at levels too low to be reported as detections by the Survey.

The Survey's findings and results are the product of a lengthy and complicated study. A joint project of EPA's Office of Drinking Water (ODW) and Office of Pesticide Programs (OPP), the Survey's design began in 1984, and involved the development of the statistical procedures, analytical chemistry, implementation methods, health advisories, and quality control procedures necessary to ensure the quality, accuracy, and reliable communication of Survey results. EPA conducted a pilot study in California, Mississippi, and Minnesota in 1987 to test Survey implementation and analytical procedures. The design of the Survey was reviewed and approved by a special subpanel of EPA's independent Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Scientific Advisory Panel in 1985 and again in 1987 after the pilot study. After extensive planning and preparation, full scale sampling for the National Pesticide Survey began in April 1988, and involved the participation of hundreds of persons from States, counties, EPA's Regional Offices, and private citizens. The final sample was collected in February 1990. More than 1300 wells were sampled, some in every State, and extensive data were collected about the wells' characteristics and condition, in addition to surrounding circumstances such as nearby pesticide use and agricultural activities, at a total cost of approximately $12 million.

The Survey's findings will help EPA characterize the nature and extent of pesticide residues in drinking water wells, and will help the Agency set priorities, prepare guidance, and implement regulatory programs. The following timeline shows the key events in the life of the Survey.

Exhibit 6
Timeline of Survey Activities


Begin Survey Design
Scientific Advisory Panel Review
Begin Pilot Study
End Pilot Study
Scientific Advisory Panel Review
Begin Rural Domestic Well Sampling
Begin Community Well Sampling
End Community Well Sampling
End Rural Domestic Well Sampling
Completion of Chemical Analysis
Completion of Data Analysis
Release of Phase I Report
1984
10/85
2/87
6/87
9/87
4/88
7/88
10/89
2/90
5/90
8/90
11/90

Discussion of Findings

The National Pesticide Survey has two principal objectives: (1) to determine the frequency and concentration of pesticides and nitrate in drinking water wells nationwide, and (2) to improve EPA's understanding of how the presence of pesticides and nitrate in drinking water wells is associated with patterns of pesticide use and the vulnerability of ground water to contamination. This Phase I Report answers the first objective. A Phase II report, planned for Spring 1991, will respond to the second objective.

EPA tested well water from wells at community water systems and from rural domestic wells for 127 analytes, including 101 pesticides, 25 pesticide degradates, and nitrate. Detections of the analytes were reported when the concentration found was greater than the Survey's specified minimum reporting limits. Of the 127 analytes, the presence of 13 was detected above their minimum reporting limits in wells sampled in the Survey. Four additional analytes were detected for which national estimates could not be made. The results indicated that nitrate is common in wells, sometimes above health based limits; pesticides are much less common. The concentrations of pesticides and pesticide degradates were usually lower than health-based limits.

The most frequently detected chemical was nitrate. EPA estimates, based on Survey results, that about 52.1% of the approximately 94,600 community water system wells and about 57.0% of the 10.5 million rural domestic wells in the country (about 5.9 million wells) contain levels of nitrate above the NPS minimum reporting limit of 0.15 mg/L.

Out of all community water system wells nationwide, however, about 1.2% (or approximately 1,130 wells) are estimated to contain nitrate over EPA's Maximum Contaminant Level (MCL) of 10 mg/L. About 2.4% of rural domestic wells, or approximately 254,000 wells, are estimated to contain nitrate over the MCL.

In all, EPA detected nitrate and 16 different pesticides or pesticide degradates in drinking water wells nationwide. The most commonly found chemicals, other than nitrate, are the pesticide degradate DCPA acid metabolites and the pesticide atrazine. Other pesticides that were detected at concentrations at or above the Survey's minimum reporting limit include alachlor, bentazon, dibromochloropropane (DBCP), dinoseb, ethylene dibromide (EDB), ethylene thiourea (ETU), hexachlorobenzene, gamma-HCH (Lindane), prometon, and simazine. In addition, three analytes (alpha-chlordane, gamma-chlordane, and beta HCH) were detected by EPA laboratories at concentrations lower than the minimum reporting limits used by the contract laboratories. Because EPA laboratories only tested 10% of the sampled wells, national estimates of the occurrence of these three chemicals are not possible. One analyte, 4-nitrophenol, was detected but a national estimate could not be produced due to limitations of the laboratory analysis method for this particular chemical.

EPA estimates that about 10.4% of the community water system wells nationwide contain detectable concentrations of at least one pesticide. About 4.2% of rural domestic wells contain a detectable pesticide concentration above the Survey's minimum reporting limit. Because the Survey's findings are based on a complex statistical design, in which national estimates are developed on the basis of a sample of wells, the best national estimates fall between a high and a low estimate. For CWS wells, the number of wells containing pesticides is approximately 9,850 wells, but the number of wells could be as high as 13,400 wells or as low as 6,330 wells. For rural domestic wells, the number of wells containing pesticides is approximately 446,000 wells, but the number of wells could be as high as 647,000 wells or as low as 246,000 wells.

Of all the pesticides and pesticide degradates detected in the Survey, DCPA acid metabolites and atrazine were the most commonly found. For DCPA acid metabolites, degradates of DCPA, the maximum concentrations detected were 7.2 μg/L (parts per billion) for CWS wells and 2.4 μg/L for rural domestic wells. The median concentrations for DCPA acid metabolites were 0.34 μg/L for CWS wells and 0.38 μg/L for rural domestic wells. The maximum concentrations of atrazine detected in Survey drinking water samples were about 0.92 μg/L for CWS wells and 7.0 μg/L for rural domestic wells. The median concentrations of atrazine were 0.26 μg/L for CWS wells and 0.28 μg/L for rural domestic wells.

How Did EPA Select Wells?

The Survey was designed to yield results that are statistically representative of the nation's CWS wells and rural domestic wells. EPA used statistical survey methods to select a nationally representative subset of CWS wells and rural domestic wells for sampling. The results are not representative of any State or local area.

First, EPA characterized all counties in the U.S. according to pesticide use and relative ground-water vulnerability – two critical factors affecting the presence of pesticides in drinking water wells. EPA concentrated on agricultural pesticide use, specified as high, moderate, low, or uncommon pesticide use. EPA specified areas of greater and lesser relative ground-water vulnerability by using a numerical classification system called DRASTIC, which considers seven factors that may affect the vulnerability of ground water to contamination – depth of water, recharge, aquifer media, soil media, topography, impact of vadose (unsaturated) zone, and hydraulic conductivity of aquifers. The Survey design called for specified numbers of wells to be sampled from areas of greater and lesser pesticide use and ground-water vulnerability.

To identify CWS wells, EPA randomly selected 7,083 community water systems from a list containing information on all public water supply systems. To ensure more precise estimation of analyte detection rates, wells in counties that are more vulnerable to ground-water contamination were slightly over-represented in the group of selected public water system wells. EPA conducted telephone interviews with representatives of the 7,083 selected systems and based on the results of the screening process identified systems eligible for sampling. Water samples from 566 wells in 50 States were collected, 540 of which were used in data analysis based on well water samples that passed quality assurance requirements.

When selecting rural domestic wells, EPA randomly chose 90 counties in 38 States as areas for sampling to represent the nation's wide range of agricultural pesticide use and ground-water vulnerability. EPA assessed ground-water vulnerability within subcounty areas and collected information from county agricultural extension agents on cropping intensity to further subdivide the counties into areas that are more or less vulnerable to the presence of pesticides in ground water. Rural domestic wells in locations with high pesticide use and high vulnerability to ground-water contamination were slightly overrepresented. Of the eligible wells, 783 wells were sampled, 752 of which were used in data analysis based on well water samples that passed quality assurance requirements.

Once the wells were selected, EPA scheduled sample collection so that wells were visited randomly over the 22 month sampling period. This schedule provided well water samples during all seasons and pesticide application cycles. This approach was used to minimize the effect of seasonal variability.

Sampling Across the Country

From April 1988 to February 1990, EPA collected water samples and well information from over 1,300 community water system wells and rural domestic wells. EPA visited each well once, collecting a minimum of 17 bottles of well water. State agencies across the country provided the sampling teams to collect samples from community water systems. EPA's contractors conducted the domestic well sampling. CWS wells were sampled in every State and rural domestic wells were sampled in 38 States.

At each well sampled, questionnaires were used to collect data necessary for the interpretation of NPS results. Data included:

- observations about the well sampled and the surrounding area;
- information from the owner/operator about well construction and agricultural and non-agricultural pesticide usage on the property where the well was located; and
- information from local area experts (such as a county agricultural extension agent) about crops, pesticide use, and land use within one-half mile of the well.

Chemical Analysis

Each water sample gathered in the National Pesticide Survey was tested for 127 analytes. Through extensive literature searches, consultation with scientific experts, and assessment of methods in the laboratory, EPA evaluated existing laboratory methods for testing the analytes. Because of the wide variety of procedures used in these methods and the large number of analytes to be included in the Survey, EPA needed methods that could efficiently test for several analytes. Ultimately, EPA used two existing analytical methods and developed six new methods specifically for the Survey. Five of these six, referred to as multi-residue methods, are each capable of detecting ten or more pesticides. These new methods have been adopted by EPA for uses other than the Survey, and are an important product of the NPS.

The chemical analyses of NPS water samples were performed at five contract laboratories and three EPA laboratories. The contract laboratories were responsible for chemical analyses of water samples collected in the field by one or more of the established methods. Two EPA laboratories were responsible for managing contract laboratories, confirming detections of pesticides in samples, and ensuring that quality control standards were maintained; the third EPA laboratory performed chemical analyses.

Health Advisories

To assist in notifying Survey participants of sampling results, EPA prepared one-page Health Advisory Summaries to explain in non-technical terms the potential health effects of exposure to pesticides. These Summaries are based on longer, more technical scientific documents called Health Advisories prepared by EPA for Survey analytes before the beginning of full-scale sampling.

Communicating Results

In EPA's ten Regions, an NPS contact was identified to enlist the cooperation of State water supply and pesticide agencies and to answer questions from the media, elected officials, and organizations interested in the Survey. At the local level, county agricultural extension agents and health officials contributed to Survey planning and implementation, provided a two-way flow of information between EPA and participating local communities, and provided expert information on local conditions.

When sampling results showed pesticide and nitrate levels below levels of health concern, EPA sent appropriate Health Advisory Summaries to well owners and operators along with Survey sampling results, usually within 2 to 3 months of sample collection.

Whenever the results of the analysis of water samples from either a community water system well or a rural domestic well indicated that a pesticide was present in the well in a concentration over the MCL or HAL, and could pose a potential health risk, EPA notified the State in which the well was located by telephone within 24 hours of confirmed analysis of the sample. The State, in turn, notified the owner or operator of the well within an additional 48 hours.

Putting Quality First

EPA made an extraordinary commitment to ensuring the validity and accuracy of Survey results. A quality assurance (QA) program covering every major component of the Survey ensured that the Survey produced high quality, statistically valid data – useful to both scientists and policy makers. EPA developed QA Project Plans for well selection, data collection and analysis, well sampling, interviewing, and laboratory analysis. During the Survey, EPA conducted numerous audits of field and laboratory activities to ensure that procedures approved as part of the QA program were followed. EPA conducted performance evaluation studies of the analytical laboratories to monitor laboratory capability.

Summary of Planned Phase II Analyses

EPA plans a number of statistical analyses using the data compiled from chemical analyses of water samples, NPS questionnaires, and other sources. These analyses will study the association of pesticides and nitrate in drinking water wells with such factors as fertilizer and pesticide use on the property where the well is located, use within one-half mile of the well, and use within the county. Studies will also address the association of pesticides and nitrate in wells with ground-water vulnerability characteristics, including depth to ground water, recharge, aquifer media, soil media, topography, impact of unsaturated zone, and hydraulic conductivity. The Phase II Report will analyze the questionnaire databases, the first-stage and second-stage DRASTIC stratification scoring results, nitrogen fertilizer and pesticide sales, and the Survey analytical results, to investigate the potential causes and consequences of pesticide residues in drinking water wells.

These analyses will include a study of whether there is an association among questionnaire responses. The hypotheses that might be tested include the following: Are there more analyte detections of chemicals associated with unconfined aquifers than with confined aquifers? Are nitrate detections associated with septic units on the property? Are there more analyte detections of chemicals associated with areas where irrigation is used? EPA is planning scientific investigations to:

- Determine the association among detections and well characteristics;
- Correlate DRASTIC subscores by individual factors (e.g., depth to ground water) with detections in rural domestic wells;
- Determine associations between pesticide use and pesticide detections in water samples;
- Prepare tables showing pesticide detections by county pesticide use estimates for specific analytes that were detected in the Survey;
- Prepare summary statistics such as frequencies of analytes detected in areas where crops are grown with known associated pesticide use;
- Conduct regression modeling for analytes with sufficient detections. These analyses will seek to identify significant relationships between variables that are not readily discernible from the analyses of well characteristics presented in the Phase I Report;
- Evaluate analytes with few detections by non-statistical review of all available data, such as marginal comments on questionnaires; and
- Compare NPS findings with other studies.

Survey Information

This Phase I Report covers Survey design, implementation, analytical chemistry, quality assurance, and summary results. In 1991, EPA will release a Phase II Report containing results and findings from analyses of the relationships between various types of information gathered during the Survey.

Chapter One: Introduction

Introduction

The National Survey of Pesticides in Drinking Water Wells (the National Pesticide Survey, the Survey, or NPS) is perhaps the most extensive monitoring survey ever undertaken to evaluate the presence of pesticides, pesticide degradates, and nitrate in drinking water wells.[1] The U.S. Environmental Protection Agency (EPA), with the assistance and cooperation of EPA Regional Offices, States, local and county officials, and private well owners, sampled 1,349 drinking water wells throughout the country for 126 pesticides and pesticide degradates, plus nitrate (a total of 127 analytes).[2] The NPS analyzed the water samples using a variety of sophisticated chemical techniques and collected additional information about the conditions in the vicinity of the sampled wells. The design and implementation of the Survey required five years -- at a cost of over $12 million. EPA has prepared this Phase I report to describe the NPS and to provide the Survey's initial findings and results. EPA plans to publish a Phase II report that will provide an expanded assessment of the Survey's findings in spring 1991.

1.1 Goals of the National Pesticide Survey

The National Pesticide Survey was designed to provide, for the first time, a statistically reliable assessment of the frequency and concentration of selected pesticides, pesticide degradates, and nitrate in the drinking water wells of the nation. EPA designed the Survey, in addition, to provide data to better understand how the presence of pesticides or nitrate in drinking water wells is associated with patterns of pesticide usage and the vulnerability of ground water to contamination.

The focus of the NPS is on the quality of drinking water in wells rather than on the quality of ground water, surface water, or drinking water at the tap. The Survey's analytic results are statistically representative of over 10.5 million rural domestic wells and wells at 38,300 community water systems (CWS) that use ground water across the country. The study has yielded valuable information on the frequency and concentration of pesticides and nitrate present in rural domestic wells and community drinking water wells on a *nationwide* basis. The NPS was *not* designed to provide a statistically valid assessment of pesticide or nitrate concentrations in wells at the local, county, or State levels.

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[1] Pesticides are chemical substances used to destroy, control, or repel undesirable plants, insects, fungi, nematodes, or animals (herbicides, insecticides, fungicides, nematocides, and rodenticides, respectively). Pesticide degradates are breakdown products of pesticide active ingredients resulting from biological processes (i.e., metabolism) or physical or chemical processes (i.e., hydrolysis, photolysis, photooxidation). The term "pesticides" throughout this report stands for both pesticides and pesticide degradates, unless otherwise indicated. Nitrate (NO_3^-) is the major nitrogen source assimilated by higher plants. It is found in some nitrogen fertilizers and/or as a result of nitrification of ammonium fertilizers. Nitrate is produced not only in soil but also in septic systems, animal feed lots, industrial waste waters, and sanitary landfills. Nitrite (NO_2^-) can be formed either as the intermediate product of ammonium (NH_4^+) during the nitrification process or as the intermediate product of nitrate during the denitrification process. Nitrate and nitrite were not separately distinguished in the Survey laboratory methods and testing. They were measured as nitrogen (N). In this report, the term "nitrate" stands for both nitrate and nitrite, unless otherwise indicated.

[2] States and private organizations recently have conducted several other surveys of well water, but they have generally concentrated on either more limited geographic areas or a more limited set of analytes than the NPS. Two of the most notable were conducted by the State of Iowa and the Monsanto Agricultural Company. The Iowa State-Wide Rural Well-Water Survey, a one-time sampling survey conducted between April 1988 and June 1989, sampled 686 sites for total coliform bacteria; nitrate, ammonia, and organic-nitrogen; other major inorganic ions (e.g., chloride, sulfate, calcium); 27 commonly-used pesticides; and selected pesticide metabolites. The National Alachlor Well Water Survey (NAWWS) conducted by the Monsanto Agricultural Company between June 1988 and May 1989 collected water samples from 1,430 wells and tested for alachlor, four other pesticides, and nitrate.

With information from the Survey, EPA will be able to better design its regulatory programs to target pesticides of concern and to refine future regulatory initiatives. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) gives EPA's Office of Pesticide Programs (OPP) authority to regulate the marketing and use of pesticides. Pesticides that are shown to pose potential hazards by their ability to leach into ground water could be subject to further registrant monitoring requirements and a range of regulatory actions, including changes in label directions, use restrictions, placement in the Special Review process, or suspension or cancellation of the pesticide's registration. EPA's Office of Drinking Water (ODW) also may use information from the Survey to implement requirements of the Safe Drinking Water Act (SDWA). New maximum contaminant levels and monitoring requirements may be proposed for pesticides found in drinking water supplies.

1.2 Overview

Ground water currently supplies drinking water to about 40 percent of the U.S. population, particularly in rural areas. In 1984, directing growing attention to the question of how to protect our ground water and citizens who drink it from the impacts of pesticides and nitrate, EPA's Office of Drinking Water and Office of Pesticide Programs began the NPS to study the extent and causes of the problem. Exhibit 1-1 is a conceptual diagram of the planning, development, implementation, and analytic phases of the NPS. It charts the development of the Survey, from design and development of analytic methods to Survey implementation, data analysis, and reporting.

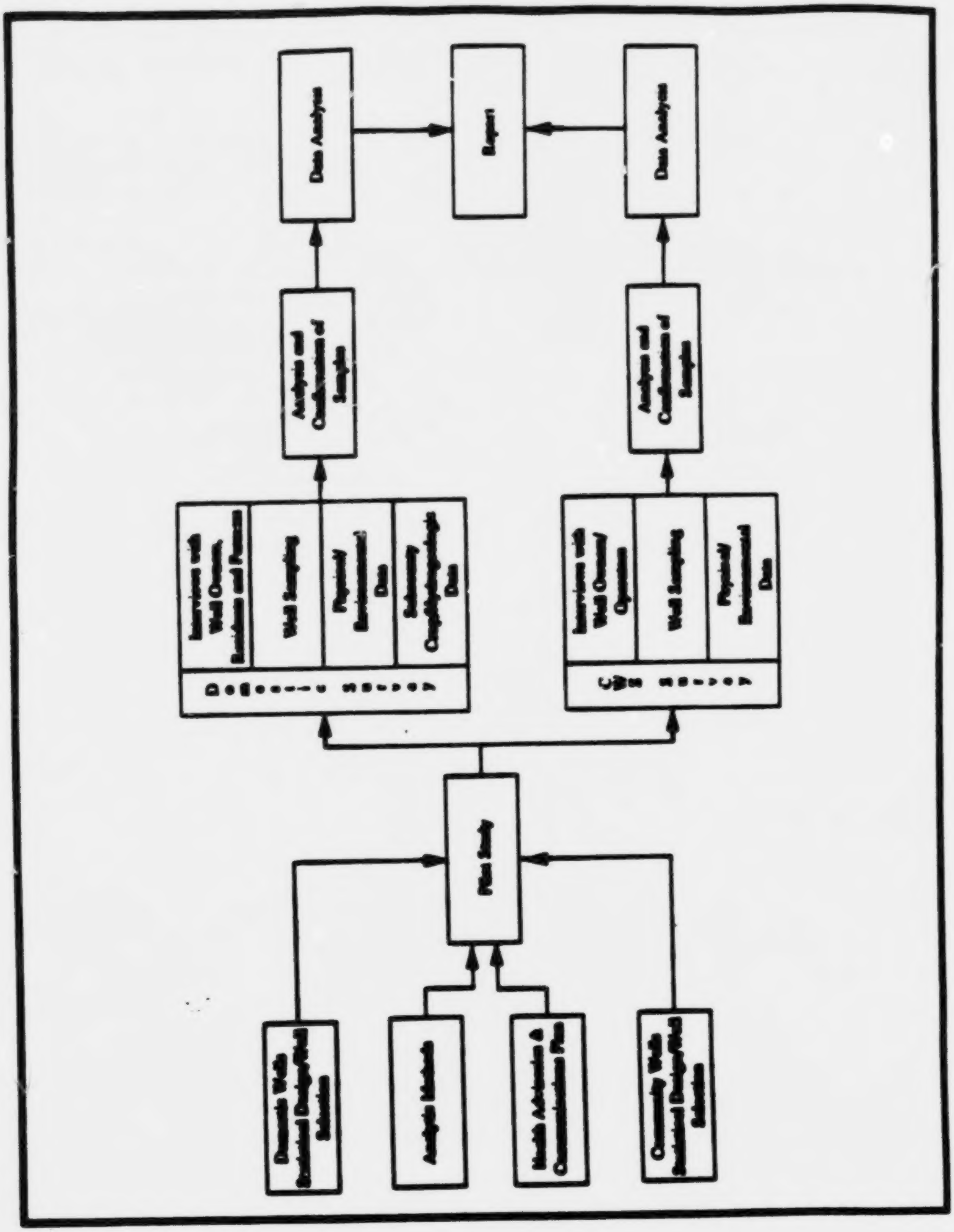
Planning of the NPS was carried out by several internal workgroups convened by ODW and OPP, as well as by expert consultants hired by EPA. Throughout the design and implementation of the Survey, EPA also consulted regularly with a workgroup of State and local representatives and with other Federal agencies.

EPA began by organizing an analyte selection workgroup, which chose a preliminary list of the pesticides and pesticide degradates to be analyzed in the Survey based primarily on their expected leaching potential, regulatory status under the SDWA, volume of sales nationally, prior occurrence in ground water, and potential health impacts.

An analytical methods workgroup conducted literature searches and consulted with pesticide analysis experts to identify appropriate analytical methods for the Survey. An important goal was to expand the capabilities of existing EPA analytical methods to identify additional analytes. Six new analytic methods ultimately were developed for the Survey, and an existing EPA method and a modification of an EPA method were used. In the course of developing analytical techniques, certain potential analytes were dropped and others added based on the capabilities of the analytic methods. The eight methods eventually developed for the NPS measured 127 analytes, including 101 pesticides, 25 pesticide degradates, and nitrate.

Following selection of the NPS analytes, an EPA health advisory workgroup developed 99 Health Advisories for pesticides and nitrate. The Health Advisories include information on physicochemical properties, uses, chemical fate, health effects, treatment, and existing criteria and guidelines. These Health Advisories are technical, scientific guidance documents developed to assist in evaluating the results of well sampling and in determining whether the levels found warrant further action. As part of EPA's effort to improve risk communication, the Agency also prepared and distributed non-technical health advisory summaries. These summaries explain the health effects of exposure to pesticides and nitrate in non-technical language. Health advisory summaries were distributed immediately to the well owners and operators of sampled wells where analytes were found in excess of health-based levels and to residents who might consume water from such wells.

Exhibit 1-1
Overview of NPS


Domestic Wells Statistical Design/Well Selection
Analytic Methods
Health Advisories & Communications Plan
Community Wells Statistical Design/Well Selection
Pilot Study
Domestic Survey
Interviews with Well Owners, Residents and Farmers
Well Sampling
Physical/ Environmental Data
Subcounty Crop/Hydrogeologic Data
CWS Survey
Interviews with Well Owners/ Operators
Well Sampling
Physical/ Environmental Data
Analysis and Confirmation of Samples
Analyses and Confirmation of Samples
Data Analyses
Data Analyses
Report

For the statistical design of the Survey, EPA used contractor support and convened two supporting workgroups. The data collection program followed EPA's formal Data Quality Objectives (DQOs) process for identifying data needs, uses, and quality goals, while remaining within resource constraints. EPA's decisions on the details of survey design were based on the work of a hydrogeologic workgroup, which selected a method of measuring hydrogeologic vulnerability, and a pesticide-use workgroup, which developed indicators for determining levels of pesticide use in counties across the country.

In March 1987, EPA launched a pilot study to field test the major components of the Survey and to provide an opportunity to make any necessary modifications to the Survey design and implementation strategy prior to initiating the full-scale national Survey. The pilot study was conducted in California, Minnesota, and Mississippi. From March through August 1987, EPA collected drinking water samples from 48 community water systems and private wells as part of the pilot study. In addition, EPA-trained State officials and contractor staff interviewed CWS operators and householders to collect information about well construction and usage and gather data about well site observations and the area in the vicinity of each well.

In September, 1987, a ten-member subpanel of EPA's FIFRA Scientific Advisory Panel (SAP) reviewed the overall survey design and the findings of the pilot study. The subpanel provided advice on a broad range of issues involved in implementing the full Survey. The subpanel review and EPA's own evaluation of the pilot study enabled EPA to make appropriate revisions and adopt more efficient and cost-effective alternatives for carrying out the Survey.

The full-scale National Pesticide Survey began in April 1988. Over the next two years, until February 1990, EPA Regional, State, and contractor sampling teams collected water samples and using Survey questionnaires gathered extensive data about well construction, pesticide use, and other factors. In total, 783 rural domestic wells and 566 community water system wells were sampled. Five contract laboratories and three EPA laboratories carried out analyses of the 17 or more water samples collected for each of the wells investigated in the Survey. Chemical analysis of the water samples was completed by May 1990. Throughout the course of the Survey, EPA followed rigorous quality assurance/quality control procedures in survey design, data collection, sample collection, chemical analysis, recordkeeping, and reporting to ensure the high quality and representativeness of the data.

Summary statistics of the NPS data are included in this Phase I Report. EPA is currently conducting an extensive assessment and further statistical analysis of NPS data, which will be released with the NPS Phase II report.

1.3 How to Use This Report

This report has been prepared to provide an initial description of the design and implementation of the EPA National Pesticide Survey, and an explanation of the Survey's initial findings and results. Specifically, this report is organized as follows:

- **Chapter Two: "Survey Design"** describes the process used to select representative subsets of community water system wells and rural domestic wells for sampling. Chapter Two describes the overall approach used to identify the study population and subpopulations and to specify the precision of sample estimates, and to respond to the recommendations of the Scientific Advisory Panel subpanel. Chapter Two also describes key design factors such as stratification, sample sizes and variances, and temporal variability.

- **Chapter Three: "Implementation of the Survey"** provides an overview of the key elements of water sampling and data collection activities during the two-year implementation phase of the Survey. It describes the training program for sampling teams and other NPS field staff, scheduling requirements, water sampling methods and procedures, and the administration of questionnaires developed for the Survey. Chapter 3 also provides a description of the extensive network of operations management, data management, and communications systems used to plan, organize, perform, track, and improve NPS implementation activities.

- **Chapter Four: "Analytical Chemistry"** describes how EPA chose the pesticides and pesticide degradates to be tested for in NPS water samples. It identifies and describes the development of the testing methods used by NPS and the activities of the analytical laboratories that conducted the testing.

- **Chapter Five: "Quality Assurance/Quality Control"** discusses the objectives, organization, and key components of the NPS quality assurance/quality control (QA/QC) program as they relate to each of the major components of the Survey. In particular, it describes the importance of the QA/QC program in monitoring and controlling information-gathering processes so that data would meet Survey design criteria for accuracy, precision, representativeness, comparability, and completeness.

- **Chapter Six: "Findings and Results"** presents summary statistical results of the chemical analyses of the water samples taken from the drinking water wells and summaries of questionnaire data. It discusses key descriptive characteristics and preliminary analysis patterns of pesticides, pesticide degradates, and nitrate; and discusses additional analyses (e.g., relational analyses) to be included in the NPS Phase II report.

- **Chapter Seven: "Survey Products"** includes a brief description of important NPS products such as Health Advisory Summaries and information on their availability.

There are five appendices to this report:

- **Appendix A: "Background"** provides an in depth review of Survey planning, development, the pilot study, and Science Advisory Panel reviews.

- **Appendix B: "Statistical Design"** is a detailed discussion of the topics outlined in Chapter Two.

- **Appendix C: "Survey Implementation"** presents detailed discussions of the topics summarized in Chapter Three.

- **Appendix D: "Questionnaire Data and Questionnaires"** provides summary statistics of the data collected using Survey questionnaires and copies of NPS questionnaires administered during the survey.

- **Appendix E: "Survey Analytes and Analytical Chemistry Tables"** provides summary information about each analyte, Minimum Quantification Limits (MQLs), and quality control results for the NPS analytes and analytical laboratories.

1.4 Additional NPS Information

This Phase I Report is part of a series of NPS reports and outreach materials. It will be followed by a Phase II report that will provide the results of additional analysis of the NPS data. In addition, the Phase II report will contain detailed information on a number of topics, including analytic methods, quality assurance, database documentation, and health advisory summaries.

EPA has prepared a number of fact sheets on selected topics concerning the National Pesticide Survey. These fact sheets are available through EPA's Public Information Center (401 M Street SW, Washington DC 20460, 202-382-2080):

Project Summary

Analytical Methods

Quality Assurance/ Quality Control

Summary of Results

Survey Analytes

How EPA Will Use The NPS Results

Survey Design

Glossary

Fact Sheet for each detected analyte

Additional information on the Survey and on pesticides in general can be obtained from the following sources:

U.S. EPA Safe Drinking Water Hotline 1-800-426-4791 (In Washington, DC -- 382-5533) Monday-Friday, 8:30 am to 4:30 pm Eastern Time	Information on regulation of pesticides in drinking water
National Pesticide Telecommunications Network 1-800-858-7378 24 hours a day	Information on health effects and safe handling of pesticides
U.S. EPA Office of Pesticide Programs (OPP) Docket Public Information Branch (H 7506C) 401 M Street, SW Washington, DC 20460 (703) 557-2805	Background documents for Survey (available for review)
National Technical Information Service (NTIS) 5285 Port Royal Road Springfield, VA 22161 (703) 487-4650	Copies of the NPS Phase I Report (available 1991) and NPS Phase II Report (when available)

Information on access to data tapes containing data generated by the Survey will be available at the conclusion of the Survey.

Chapter Two: Survey Design

Introduction

This chapter explains the key elements of the NPS survey design and provides an overview of how the wells were selected for the two categories of wells included in the Survey – community water system (CWS) wells and rural domestic wells. Section 2.1 describes the key elements of the Survey design. Section 2.2 defines community water systems and describes the methods used to obtain a sample of the population of wells from those systems. Section 2.3 defines rural domestic wells and describes the methods used to obtain a sample of the population of those wells. Details of survey design, including the statistical basis of the sample sizes and stratification, are described in Appendices A and B.

2.1 Key Elements of Survey Design

The National Pesticide Survey was designed to collect samples of drinking water from wells across the country. The NPS also collected information about well construction, physical surroundings, and land use for investigation of possible relationships between the analytical results, ground-water vulnerability, and pesticide use.

EPA and its consultants designed the Survey to yield results that are statistically representative of the nation's domestic and community water system drinking water wells. Statistical survey methodology was used to select representative subsets of these wells for sampling. Water samples were then obtained from those wells. From these sampling results, NPS statisticians can produce national estimates, relating the information obtained about the wells from which water samples were obtained to the entire population of drinking water wells.

The key elements of the NPS survey design included the stratification used in the selection of representative samples of wells, the method used to determine the numbers of wells from which water samples should be obtained, evaluation of the survey design by an outside panel of scientific experts, and the development of the NPS questionnaires.

2.1.1 Design Goals

EPA's Office of Pesticide Programs and Office of Drinking Water established the information goals for the Survey soon after planning began in 1984, and those overall goals in turn formed the basis of the survey design. The two major design goals of the Survey are:

- To determine the frequency and concentration of the presence of pesticides and nitrate in drinking water wells nationwide; and
- To examine the relationships of the presence of pesticides and nitrate in drinking water wells to patterns of pesticide use and ground-water vulnerability.

Full-scale planning of the NPS began in 1984, and the background and early stages of that process are described in Appendix A. This chapter provides a conceptual description of the NPS survey design, rather than an historical account. The basic conceptual steps in the design of the Survey were:

- Defining the survey population to be studied;
- Defining the criteria for stratification;

- Identifying the subgroups of the population (the domains of interest) to form the basis for the design; and

- Specifying the level of precision to be associated with the Survey estimates.

2.1.2 Survey Population

Before determining the size of the sample of the well population that should be selected, the Survey designers first needed to estimate the size of the well population as a whole.[3] Rural domestic wells were defined as drinking water wells that supply occupied housing units located in rural areas of the United States, except for wells located on government reservations. The Census Bureau defines rural areas as households outside of incorporated or unincorporated places with 2,500 or more population and outside of urban fringe areas. The number of private rural domestic wells was estimated based on 1980 Census Bureau data as 13 million. The estimate of the number of community well systems was based on the Federal Reporting Data System (FRDS), maintained by the EPA Office of Drinking Water which contains information on public water supply systems. FRDS listed about 51,000 systems in the United States for the period from July 1984 through June 1985.

2.1.3 Stratification and How Stratification Criteria were Determined

The NPS used a process known as stratification in selecting the subsets of CWS and rural domestic wells for sampling. In general, stratified designs are used to improve the accuracy of the estimates by controlling the distribution of the sample of the population from which data will be collected. The selection of the samples of the population of CWS and rural domestic wells took place in stages, with additional selection criteria at each stage. The resulting final samples of the population of CWS and rural domestic wells were controlled for two specific criteria: pesticide use and ground-water vulnerability in the county or sub-county area in which the wells to be sampled were located.

The first step in well selection (first-stage stratification) was common to both CWS and rural domestic wells. Each of the 3,137 counties or county equivalents in the U.S. (which were determined to be conveniently-sized units for constructing the first-stage sampling frame) was categorized by pesticide use and ground-water vulnerability. The first-stage sampling frame was stratified in this manner to ensure that samples were taken from wells located in areas with different levels of pesticide use and ground-water vulnerability.

In 1984 when the survey design was begun, only limited data were available on pesticide use. Originally, all types of pesticide use – agricultural, home and garden, industrial, rights-of-way, commercial, and government – were considered as stratification criteria. Because agricultural use of pesticides was significantly higher than other uses, agricultural pesticides had been found in ground water, and data on agricultural pesticide use were better than for other categories of use, agricultural pesticide use was chosen as one of the stratification criteria.

EPA developed county-level pesticide use estimates for each county, based on 1982 Census of Agriculture information for crop acreages and on private marketing data (provided by Doane Marketing Research, Inc.) for pesticides. Total acreage using 63 specific chemicals was calculated for 28 crops. The acreage to which a specific chemical was applied in a county was estimated; acreages for all chemicals were summed, and the total expressed as a percentage of the total area of the county. Agricultural pesticide use was described as high, medium, low, or uncommon, based on the following criteria:

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[3] These numbers represent the Agency's estimate of the population of wells at the beginning of the Survey. Estimates of the well population based on the Survey results are smaller: 10.5 million rural domestic wells and about 94,600 wells at 38,300 community well systems.

- **High Pesticide Use.** Agricultural pesticides applied to the equivalent of 75 percent or more of the total county area;
- **Moderate Pesticide Use.** Agricultural pesticides applied to the equivalent of between 30 percent and 74 percent of the total county area;
- **Low Pesticide Use.** Agricultural pesticides applied to the equivalent of between 5 percent and 29 percent of the total county area; and
- **Uncommon Pesticide Use.** Agricultural pesticides applied to the equivalent of less than 5 percent of the total county area.

In order to examine any relationships between levels of pesticides and nitrate and hydrogeologic characteristics conducive to ground-water contamination, NPS developed a system for identifying a variety of hydrogeologic conditions and classifying them into areas of relatively greater or lesser ground-water vulnerability on a county-wide basis for the purpose of sample stratification. One of the goals of the Survey was to test this system and determine if it functioned as a useful sorting technique.

The Agricultural DRASTIC classification system, one variation of an indexed scoring system that had already been developed by the National Water Well Association, was modified for use in the Survey by Research Triangle Institute. DRASTIC is an acronym for a ranking system for evaluating the vulnerability of aquifers to pollution beneath a particular land area. It is derived from the seven hydrologic factors considered in the ranking system: depth of water, recharge (net), aquifer media, soil media, topography (slope), impact of vadose zone, and conductivity (hydraulic) of the aquifer. Another proposed classification system, the Great Soil Groups, was not chosen because its component factors apply only to the top 30 inches of soil. Site-specific classification systems were precluded for a large-scale national survey such as NPS because of the large amounts of data such systems require. Design of an entirely new system for use by the Survey was precluded by the cost and time that would have been needed to develop it.

To represent relative ground-water vulnerability, a county-level DRASTIC hazard index was developed for each of the 3,137 U.S. counties, based on a number of information sources and the experience and judgment of hydrogeologists familiar with particular regions. The sources of information included:

- U.S. Geologic Survey (USGS) 7.5 minute quadrangle maps (or 15 minute quadrangle maps where 7.5 minute maps were not available);
- USGS Geologic Maps and USGS Groundwater Maps (where available);
- U.S. Department of Agriculture, Soil Conservation Service Soil Survey Maps; and
- Materials from State geologic surveys, Departments of Water and Natural Resources, Departments of Environmental Protection, regional planning authorities, county and regional water supply agencies, private water supply firms, hydrogeologic and engineering firms, professional associations, and local colleges and universities.

These DRASTIC scores were used to divide counties into areas of relatively high, moderate, and low ground-water vulnerability, as follows:

- **High.** County-level DRASTIC score that identifies the most highly vulnerable 25 percent of households with wells within each of the pesticide use strata.
- **Moderate.** County-level DRASTIC score that identifies the most highly vulnerable 50 percent of households with wells within each of the pesticide use strata.

- **Low.** Remainder of the area frame (i.e., counties with the lowest DRASTIC scores identifying 25 percent of households with wells within each of the pesticide use strata).

Thus, the DRASTIC scores, together with the pesticide use criteria, result in a matrix of twelve strata. The strata, and their associated DRASTIC scores, are described in Exhibit 2-1.

Exhibit 2-1
Strata for NPS First-Stage Survey Design

Agricultural Pesticide Use	Ground-Water Vulnerability	Defining DRASTIC Scores
High	High	148 and over
High	Moderate	116 to 147
High	Low	115 and under
Moderate	High	163 and over
Moderate	Moderate	113 to 162
Moderate	Low	112 and under
Low	High	159 and over
Low	Moderate	132 to 158
Low	Low	131 and under
Uncommon	High	152 and over
Uncommon	Moderate	121 to 151
Uncommon	Low	120 and under

2.1.4 Definition of Domains of Interest and Design Assumptions

The NPS survey design identified particular subsets of the entire population of drinking water wells that were of special interest to the Survey. These subsets, known as domains of interest, constituted categories of wells about which it was particularly important to obtain information. The seven domains of interest were:

1. Community water system wells nationally;
2. Community water system wells in counties having the highest average ground-water vulnerability;
3. Rural domestic wells nationally;
4. Rural domestic wells in counties with the highest average pesticide use;
5. Rural domestic wells in counties with the highest average ground-water vulnerability;
6. Rural domestic wells in "cropped and vulnerable" county subregions; and
7. Rural domestic wells in counties with the highest average pesticide use and ground-water vulnerability.

2.1.5 Precision Requirements and Domain Sizes

In order to determine the number of wells to be sampled from each of the domains of interest (the domain sizes) Survey designers had to specify the level of precision of the Survey that they wanted to achieve. Different assumptions about the "true" proportion of all wells that contain pesticides were evaluated.

Alternative domain sizes and precision requirements were evaluated from the standpoint of EPA policy, fiscal, and program considerations. These alternatives, with cost estimates for collecting data, were then evaluated mathematically to determine the sizes of the sample of the population at each stage within each of the design strata that met EPA's cost ceilings.

Survey designers ultimately decided to structure the Survey so that it provided a 90 percent probability of detecting the presence of pesticides in the sample of CWS wells if 0.5 percent of all community water systems in the country contained pesticides. This is fairly conservative; the probability of detection would of course be much better if more than 0.5 percent of all CWS in fact contain pesticides.

The domestic well statistical design was intended to yield a range of probabilities of detecting the presence of pesticides in different domains. The strategy was to employ a sampling design to obtain the highest power (power being the probability of detecting contamination when contamination actually exists) in the vulnerable/high use counties and in the cropped/vulnerable subcounty areas of those counties, and to accept a slightly lower power in the national level estimates. Areas of particular concern were oversampled in order to yield better, more precise estimates. Thus, the likelihood of the Survey detecting the presence of pesticides in domestic wells was 63 percent at the national level (assuming a 1 percent rate nationally), but the Survey had a 97 percent chance of detecting pesticides in cropped and vulnerable areas (assuming a 0.25 percent actual rate in these areas). The precision requirements for the domains of interest eventually chosen are provided in Exhibit 2-2.

Exhibit 2-2
NPS Domain Sizes and Confidence Levels

Domain	Percentage of the Specified Domain*	Probability of Detection**
CWS wells nationally	0.5%	90%
CWS wells in counties with highest average ground-water vulnerability	0.1%	60%
Rural domestic wells nationally	1.0%	63%
Rural domestic wells in counties with highest average pesticide use	0.14%	75%
Rural domestic wells in counties with highest average ground-water vulnerability	0.25%	75%
Rural domestic wells in cropped and vulnerable parts of counties	0.25%	97%
Rural domestic wells in counties with highest average pesticide use and ground-water vulnerability	0.3%	47%

* Wells in the domain assumed to contain pesticides as a percentage of all wells in the population.

** Probability of at least one detection, given the relative domain size.

2.1.6 Pilot Study

EPA conducted a pilot study from March to August, 1987, to test the major components of the Survey and to provide an opportunity for any necessary revisions or modifications before the full Survey. The pilot study was conducted in three States: California, Minnesota, and Mississippi, to provide geographic diversity and because of their high level of interest and cooperation.

Water sampling was conducted at 48 wells in the pilot study, including both rural domestic wells and community water system wells. In addition, interviews were conducted with householders regarding the use and construction of their wells, and data were collected on conditions within the immediate vicinity of the well and within a half mile radius of the well. CWS wells in each pilot State were sampled by State health department officials. Questionnaires on the construction and characteristics of the wells also were administered to CWS operators.

The pilot study led to improved procedures and techniques in several areas. Refinements were made in the interview questionnaires, training manuals, and sampling communications procedures, in anticipation of the full Survey. In addition, the pilot study raised specific issues related to the Survey design, which were analyzed and presented to a subpanel of the FIFRA Science Advisory Panel in September 1987.

2.1.7 Design Review

In 1985, at the initial design stage of the Survey, and again in 1987, prior to implementation of the full Survey, the Survey design was submitted for peer review to a subpanel of EPA's FIFRA Scientific Advisory Panel. Public meetings of the subpanel were held to discuss the subpanel's conclusions. In October, 1987, the SAP subpanel commented on four topics:

1. The type and complexity of data needed to meet Survey objectives, particularly the county DRASTIC assessments and the cropping and pesticide use data;
2. The proposed method for selecting CWS wells for water sampling;
3. The issue of temporal variation (seasonal patterns of pesticide application, precipitation, and other similar phenomena), as a factor influencing when and in what concentration pesticides and nitrate impact drinking water wells, and how to address temporal variation in water sampling; and
4. Issues involving the stability of the analytes in water samples over time.

Recommendations of the SAP subpanel were received and reviewed by EPA. The changes made to the survey design to incorporate the subpanel's suggestions are described briefly in this chapter. Additional details on the SAP subpanel review are provided in Appendix A.

2.1.8 Survey Data Objectives and Questionnaire Development

EPA ultimately developed nine questionnaires for the NPS. Following the pilot study and SAP subpanel review, additional questions collecting well-specific information, pesticide use data, and land use data were added to the questionnaires. The key information sought and the need for this information is described below for each questionnaire:

- **Team Leader Introduction and Well Observation Record.** The *Team Leader Introduction* was developed to assist in ensuring the proper information was gathered prior to the actual sampling event. The sampling team leader used the introduction to introduce the sampling team to the well owner/operator, confirm eligibility, and provide an overview of the Survey objectives. In cases where the CWS was a multiple well system, the Team Leader Introduction was used to identify the specific well to be sampled through a random selection process. For rural domestic wells, it was used to obtain written consent from the well owner/resident to sample the well.

The *Well Observation Record* was completed by the Team Leader. It recorded the Team Leader's observations about the well and the surrounding area, including topography, soils, water treatment and storage systems, well housing, and additional observations deemed important because of their potential influence on pesticide migration into the well sampled. Well-specific notes, including a sketch of the well system indicating the sampling port or tap, and a sketch of local land features around the well also were recorded in the Well Observation Record.

- **CWS and Domestic Well Main Questionnaires.** These questionnaires collected detailed information regarding water use, water treatment, well construction, and non-farm and farm pesticide use on the property where the well is located.

- **Domestic Well Second-Stage County Agricultural Extension Agent Questionnaire.** This questionnaire gathered cropping and pesticide use information for 84 of the domestic well survey counties (such data had previously been collected for six counties as part of the pilot study). Information collected in this questionnaire was used to identify areas ("cropped and vulnerable") in the counties from which a larger proportion of wells would be selected (over-sampling areas). Information was gathered on what pesticides were used within the county to be used for statistical analyses in the Phase II report.

- **Local Area Expert Questionnaires.** These questionnaires were administered to persons familiar with local conditions and use of land and pesticides surrounding the well being sampled. For CWS, this information was usually collected from the county agricultural extension agent. For rural domestic wells, this questionnaire was administered to the county agricultural extension agent who responded in the Second-Stage County Agent Questionnaire. The county agent was recontacted after all the wells in a county were sampled to obtain additional information about local conditions and use of land and pesticides within one-half mile of the well. Information collected from this questionnaire can be compared to the general agricultural practice responses in the second-stage questionnaire.

In addition to these questionnaires administered in the field, two screening questionnaires, administered by telephone, were used to identify the wells to be sampled. The CWS Screening Questionnaire was developed in part to respond to the SAP subpanel recommendations on selection of CWS wells.

- **Screening Questionnaires.** The screening questionnaires were developed to identify a national sample of community water systems and rural domestic wells that met specific NPS eligibility criteria. The *CWS Screening Questionnaire* was designed to confirm the eligibility of 7,088 CWS, which were randomly selected from more than 51,000 CWS listed in the Federal Reporting Data System (FRDS), and which used ground water as a source of drinking water. A random subsample of 599 CWS wells was then identified from the eligible CWS for inclusion in the community drinking water sampling survey. The *DWS Screening Questionnaire* was designed to identify a sample of eligible households possessing a drinking water well by county subregions and to obtain the well owner's verbal approval for sampling.

2.1.9 Scheduling and Temporal Variability

In response to the recommendation by the SAP subpanel that the Survey design address temporal variability, EPA selected a method of allocating sampling dates to wells randomly across the data collection period, separately for each stratum, to minimize the possibility of temporal bias. The capacity of the analytic laboratories established the ceiling for the number of wells that could be sampled in a particular period. Within that ceiling, EPA allocated counties selected for domestic well sampling to two-week time periods, spread over an 18-month period, from September 1988 to February 1990. (Domestic wells selected from counties in the three States included in the pilot study were sampled from April through August 1988.) Sampling of community water systems was similarly spread out in two-week periods from August 1988 to December 1989. Not all CWS wells in a county were sampled in the same time frame. An example of the sampling pattern eventually adopted for CWS wells in one State is shown in Exhibit 2-3. State sampling teams scheduled sampling and data collection for a date during one of the two weeks.

Exhibit 2-3
Example of Sampling Schedule for CWS in One State

				Sampling Time Frame	
Community Well Systems	Stratum	Number of Wells in System	Week for Sampling Confirmed With CWS	Potential Sampling Week 1	Potential Sampling Week 2
CWS 1	4	2	10/17/88 - 10/21/88	10/17/88 - 10/21/88	10/24/88 - 10/28/88
CWS 2	11	3	12/12/88 - 12/16/88	12/12/88 - 12/16/88	01/02/89 - 01/06/89
CWS 3*	12	40	01/09/89 - 01/13/89	01/09/89 - 01/13/89	01/16/89 - 01/20/89
CWS 4	8	2	01/09/89 - 01/13/89	01/09/89 - 01/13/89	01/16/89 - 01/20/89
CWS 5	7	2	02/20/89 - 02/24/89	02/20/89 - 02/24/89	02/27/89 - 03/03/89
CWS 6	4	3	03/06/89 - 03/10/89	03/06/89 - 03/10/89	03/13/89 - 03/17/89
CWS 7	11	1	03/20/89 - 03/24/89	03/20/89 - 03/24/89	03/27/89 - 03/31/89
CWS 8	12	2	04/17/89 - 04/21/89	04/17/89 - 04/21/89	04/24/89 - 04/28/89
CWS 9	11	12	05/01/89 - 05/05/89	05/01/89 - 05/05/89	05/08/89 - 05/12/89
CWS 10	7	20	05/01/89 - 05/05/89	05/01/89 - 05/05/89	05/08/89 - 05/12/89
CWS 11	4	1	05/15/89 - 05/19/89	05/15/89 - 05/19/89	05/22/89 - 05/26/89
CWS 12	10	2	06/12/89 - 06/16/89	06/12/89 - 06/16/89	06/19/89 - 06/23/89
CWS 3*	12	40	08/07/89 - 08/11/89	08/07/89 - 08/11/89	08/14/89 - 08/18/89
CWS 13	11	2	09/04/89 - 09/08/89	09/04/89 - 09/08/89	09/11/89 - 09/15/89
CWS 14	8	1	12/04/89 - 12/08/89	12/04/89 - 12/08/89	12/11/89 - 12/15/89

* Note: Two wells from CWS 3 sampled in different sampling periods.

The following two sections provide additional details on the unique features of the Survey design for CWS and rural domestic wells, respectively.

2.2 Community Water Systems

Community water systems are defined under the Safe Drinking Water Act and its regulations as systems providing piped drinking water with at least 15 connections and/or serving a population of at least 25 persons who are permanent residents of the service area. For the purposes of the NPS, a CWS was further defined as a system with at least one working well used to obtain drinking water. All such systems are listed on the Federal Reporting Data System (FRDS) maintained by EPA's Office of Drinking Water. Only community systems listed on FRDS for the period July 1984 through June 1985 were eligible to be included in the Survey. Systems that obtain water exclusively from surface water were excluded, because a community system had to be listed on FRDS as an "active" system, with at least one well under the operational control of the system.

A two-stage statistical design was adopted for community water systems, based on the pilot study conducted in 1987 and the recommendations of the SAP subpanel. A summary of the community well selection process is illustrated in Exhibit 2-4 on page 16.

2.2.1 First-Stage Stratification

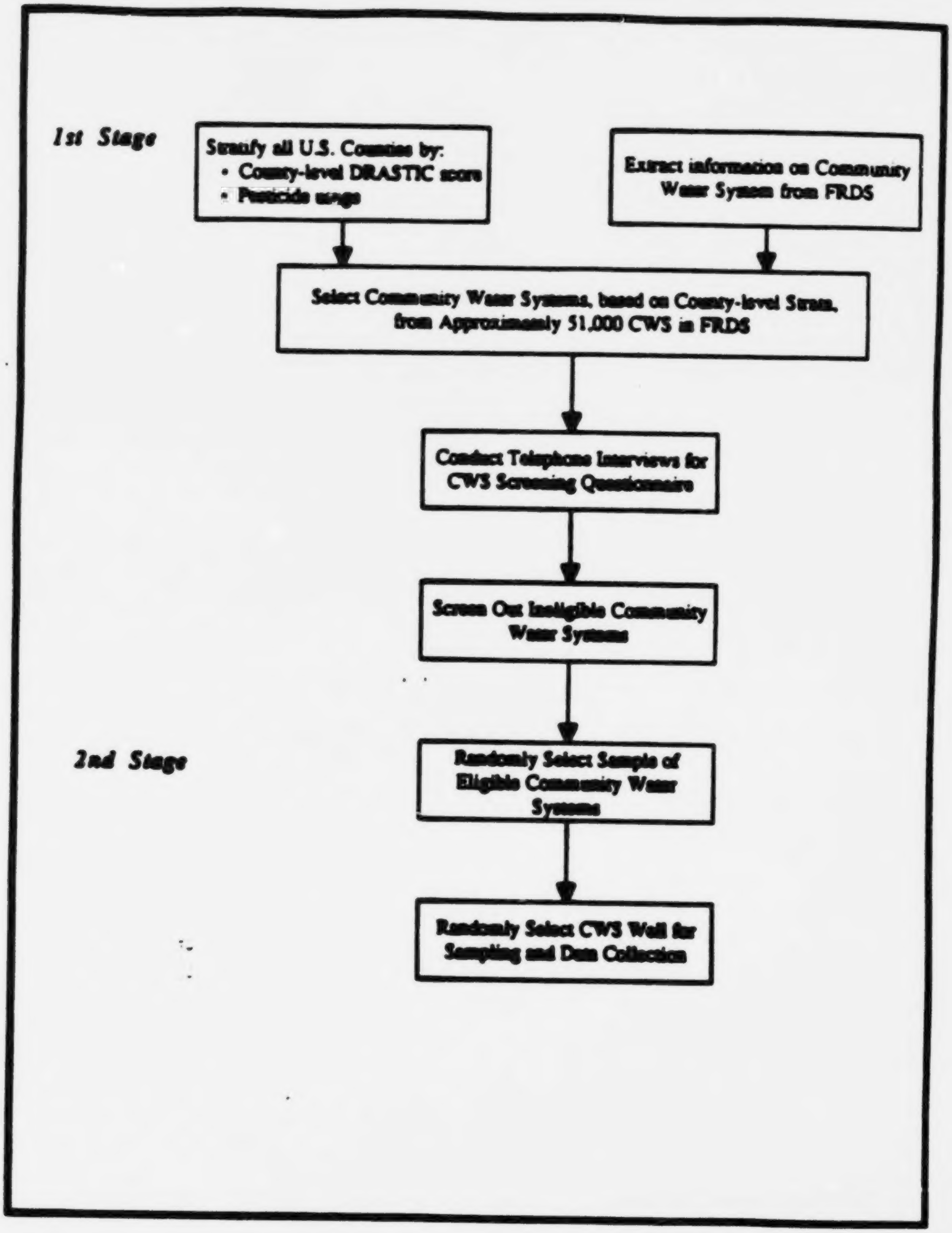
As Section 2.1 described, the sample frame for the CWS first-stage stratification was the FRDS. Records in FRDS indicated that about 51,000 CWS using ground water as a source of drinking water existed in the country, and EPA extracted information on those systems from FRDS in December 1985. A sample of 7,083 systems was then randomly selected, stratified by the pesticide use (high, moderate, low, or uncommon) and ground-water vulnerability (high, moderate, or low) of the county in which each CWS was located. To improve the reliability of estimates made for the subset (domain) of CWS wells in the high vulnerability strata, the Survey was designed to collect higher percentages of water samples from these strata (i.e., to "oversample"). The Survey was not designed to oversample CWS wells in areas of high agricultural pesticide use, because CWS wells, which are frequently located in urban areas, were expected to be less likely to be impacted by agricultural use. Distribution of the first stage CWS samples across strata is described in Exhibit 2-5.

Exhibit 2-5
CWS First-Stage Stratification Results

Stratum	Pesticide Usage	DRASTIC Score	Universe Size*	Sample Rate	Sample Size*
1	High	High	1,310	.22	293
2	High	Medium	2,669	.10	276
3	High	Low	1,432	.10	148
4	Medium	High	2,183	.25	555
5	Medium	Medium	3,362	.10	356
6	Medium	Low	2,569	.10	285
7	Low	High	3,578	.24	866
8	Low	Medium	7,199	.10	771
9	Low	Low	5,546	.12	647
10	Uncommon	High	3,472	.22	777
11	Uncommon	Medium	9,511	.11	1,069
12	Uncommon	Low	7,981	.13	1,081
			50,771		7,083

* Number of systems

Exhibit 2-4
Community Well Selection Process


1st Stage
Stratify all U.S. Counties by:
• County-level DRASTIC score
• Pesticide usage
Extract information on Community Water System from FRDS
Select Community Water Systems, based on County-level Strata, from Approximately 51,000 CWS in FRDS
Conduct Telephone Interviews for CWS Screening Questionnaire
Screen Out Ineligible Community Water Systems
2nd Stage
Randomly Select Sample of Eligible Community Water Systems
Randomly Select CWS Well for Sampling and Data Collection

2.2.2 Second-Stage Stratification

The pilot study conducted in 1987 at 10 community water systems in three of the States selected for the nationwide sample identified a number of issues affecting the sample selection. Although FRDS represented the best and most complete list of community water systems nationally, the pilot study indicated that certain data elements in FRDS were not always complete or consistent. In California, one of the States included in the pilot study, a large proportion of the sample was non-community rather than community water systems. This problem was believed to be limited to California, and was resolved by drawing a compensating, augmented national sample. A second, more widespread, problem was that the FRDS records were sometimes a mixture of individual systems and parent companies operating several systems at different locations. The mixture of individual systems and parent companies in FRDS suggested that the sampling frame contained multiplicities (i.e., a single system could be associated with more than one member of the frame). Finally, the pilot study developed information suggesting that the selected systems had more wells than were shown on FRDS or anticipated in the survey design. The Survey had been planned to sample each well in each selected system, based on an estimate of an average of 1.5 wells per system, and on that basis to estimate the number of community water systems in the country that have at least one well containing pesticides. Instead, however, the pilot study results indicated that approximately 5.75 wells would have to be sampled per system, with significant additional data collection costs.

These problems were addressed in two ways. First, questions were added to the CWS Screening Questionnaire to assist in determining the number of times each system in the sample might have occurred in the group from which the sample was chosen. Questions were included asking the CWS to identify its parent company, if any, and procedures were developed to determine if the parent company was also part of the frame. The results of this screening allowed more accurate estimates of the number of CWS and CWS wells in the country to be made. Survey results are representative of the wells used by an estimated 38,300 CWS. Secondly, in the second-stage stratification, community water systems were selected with probabilities of selection proportional to size. The measurement of size was determined by the number of wells in a system. Community water systems with very large numbers of wells were automatically included in the Survey, and given the chance to be selected numerous times. (Ultimately, more than one well was expected to be sampled at 23 systems.) Each time one of these large systems was selected, a new one of its wells was randomly selected for the Survey (i.e., if a system was selected three times, three of its wells were selected).

Telephone interviews using the CWS Screening Questionnaire were held with the first-stage sample of 7,083 CWS. The names and addresses of all of these systems were reviewed by State and EPA Regional staff before any screening interviews were conducted. The purposes of the screening survey were to establish initial contact with the system owner/operator, verify eligibility, obtain cooperation with the Survey, and verify the number of wells at the CWS. The results of the screening produced a frame of 5,660 eligible systems from which to select the wells from which water samples and other data would be collected.

Distribution of the CWS samples across strata following second-stage stratification and sample selection is described in Exhibit 2-6. A sample of 599 eligible systems was selected with probabilities proportional to their number of wells. During the course of the Survey problems were encountered that made it impossible to include certain CWS selected earlier. These problems included:

- Changes in CWS operations, so that at least one eligible well was no longer under the operational control of the system;
- An incorrect number of operating wells reported by the CWS owner/operator during the screening survey; or
- Inability to sample a well prior to the point of treatment of the water.

Therefore, an additional 68 CWS were randomly selected in August 1989 from the frame of eligible systems to ensure that the Survey met the minimum sample size criteria, while minimizing the chance of selecting a member of the original sample.

Exhibit 2-6
CWS Second-Stage Stratification Results

Stratum	Pesticide Usage	DRASTIC Score	Design Sample Size*
1	High	High	27
2	High	Medium	26
3	High	Low	14
4	Medium	High	45
5	Medium	Medium	32
6	Medium	Low	25
7	Low	High	73
8	Low	Medium	68
9	Low	Low	53
10	Uncommon	High	71
11	Uncommon	Medium	90
12	Uncommon	Low	75
			599

* Number of systems selected, including allowances for inability to sample prior to treatment. Minimum desired sample size after dropout was 564.

2.3 Rural Domestic Wells

Rural domestic wells were defined as private water wells supplying occupied housing units located in rural areas in the U.S., except government reservations. No comprehensive listing of domestic water wells, similar to FRDS for CWS, existed to serve as a sampling frame. EPA therefore developed a sampling method to randomly select rural domestic wells that emphasized geographic areas that have high pesticide usage and ground-water vulnerability. A summary of the domestic well selection process is illustrated in Exhibit 2-7.

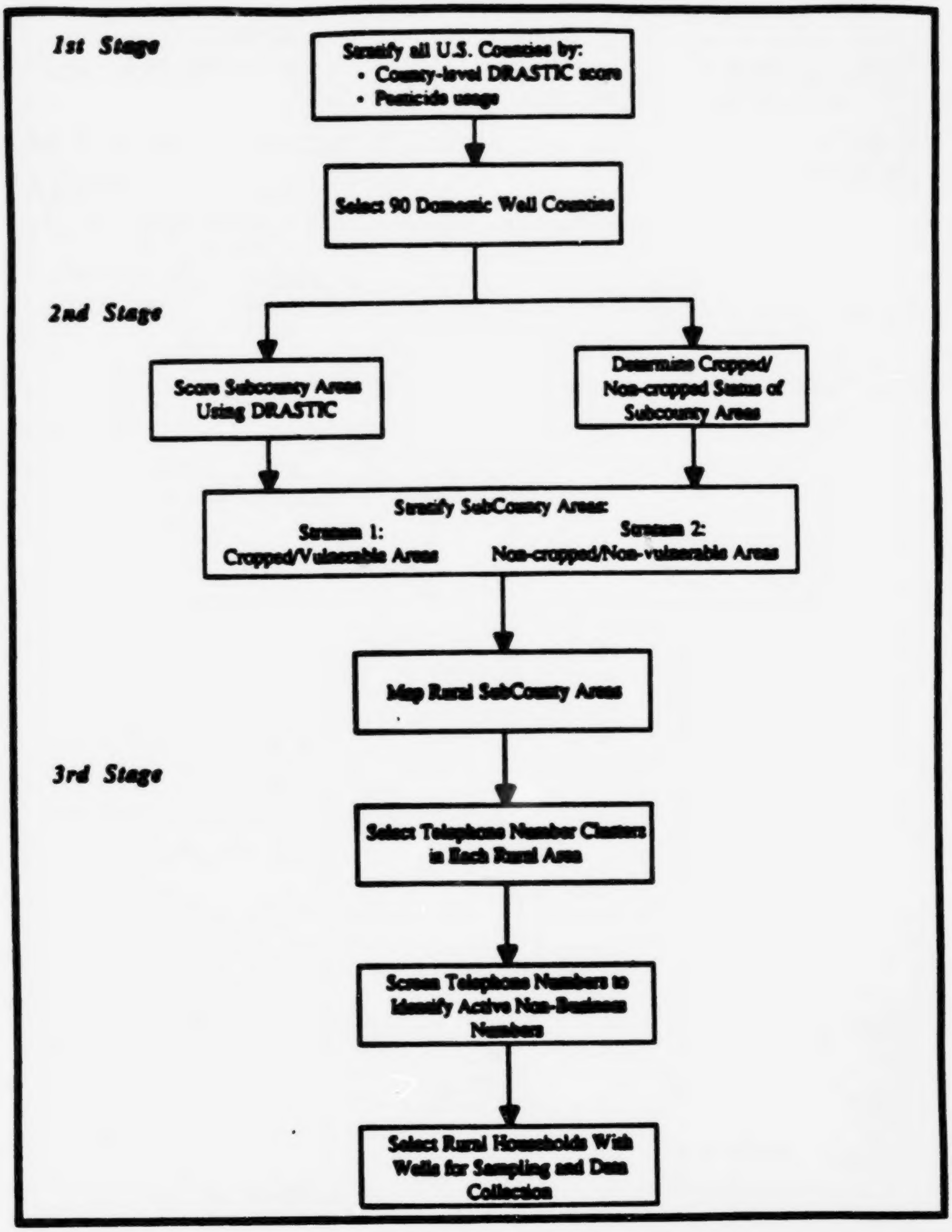
2.3.1 First-Stage Stratification

As Section 2.1 described, in the first stage EPA stratified all of the counties and county equivalents in the U.S. by pesticide use and ground-water vulnerability. Ninety counties then were selected as the primary sampling units in the first stage. The selection of 90 Survey counties was based on the stratification rules and Census Bureau estimates of the number of households with wells per county.

2.3.2 Second-Stage Stratification

In the second-stage stratification, DRASTIC vulnerability scores were assigned to subregions of each of the 90 Survey counties, to divide them into regions with common levels of ground-water vulnerability. The output of the second-stage DRASTIC scoring process was a map for each of the 90 counties, delineating the hydrogeologic settings and associated vulnerability scores, accompanied by a list of reference materials for each county. DRASTIC scoring for second-stage stratification was done using USGS 7.5-minute quadrangle maps and geologic maps to identify boundaries between cropping areas. The boundaries were drawn in by hand on USGS maps and quantified using a digitizing table and computer system with graphics software.

Exhibit 2-7
Domestic Well Selection Process


1st Stage
Stratify all U.S. Counties by:
• County-level DRASTIC score
• Pesticide usage
Select 90 Domestic Well Counties
2nd Stage
Score Subcounty Areas Using DRASTIC
Determine Cropped/ Non-cropped Status of Subcounty Areas
Stratify SubCounty Areas:
Stratum 1: Cropped/Vulnerable Areas
Stratum 2: Non-cropped/Non-vulnerable Areas
Map Rural SubCounty Areas
3rd Stage
Select Telephone Number Clusters in Each Rural Area
Screen Telephone Numbers to Identify Active Non-Business Numbers
Select Rural Households With Wells for Sampling and Data Collection

Personal interviews were held with county agricultural extension agents to determine cropping intensity, which was used as a surrogate measure for pesticide use intensity. The County Agent Questionnaire also provided information for specifying the amount of pesticide use in each quadrangle relative to the rest of the county (i.e., higher, lower, or about the same). Information from the questionnaire was used to classify quadrants (USGS 7.5-minute quadrangle maps) of each of the 90 counties into one of three agriculture cropping categories: (1) more than 50 percent of the total area of the county cropped; (2) 25 to 50 percent of the area cropped; and (3) 25 percent or less of the area cropped.

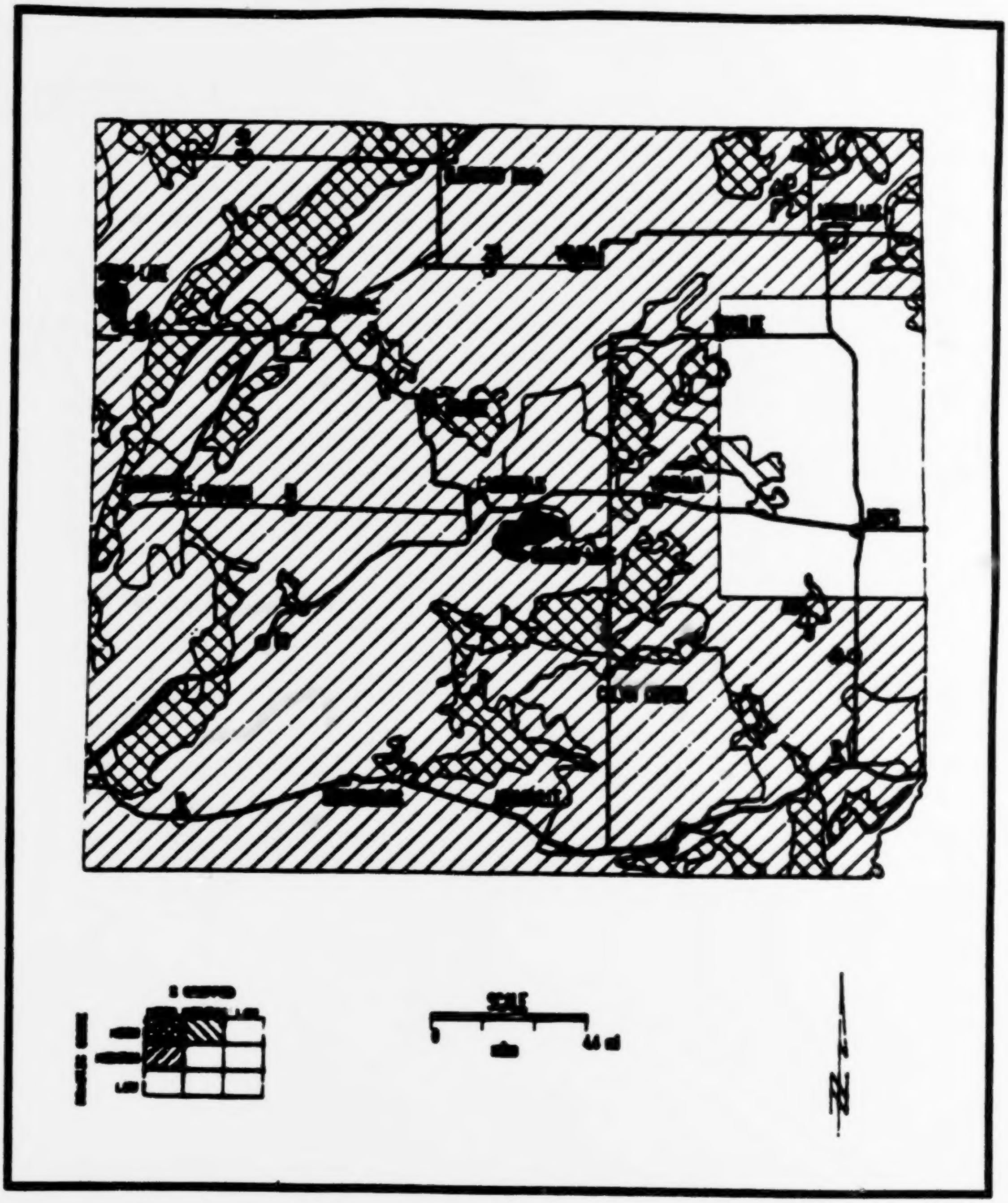
EPA next partitioned the total area of each county into two strata, by combining cropping category maps with DRASTIC vulnerability maps. One stratum contained the more heavily cropped and more vulnerable part of the county; the remainder of the county was designated as the second stratum. The cropped and vulnerable definition is illustrated in Exhibit 2-8, with the cropped and vulnerable stratum shaded. Composite maps showing the cropped and vulnerable areas of each county were prepared using computer-assisted mapping techniques. These maps were used to define areas from which a larger proportion of wells would be selected. Exhibit 2-9 provides an example of a second-stage "cropped and vulnerable" map.

Exhibit 2-8
Cropped and Vulnerable Stratum for Subcounty Regions

Cropping Intensity by Land Area

Drastic Scoring	High > 50%	Medium 25-50%	Low < 25%
High >180	■	■	
Medium > 120	■		
Low < 120			

Exhibit 2-9
Example of Second-Stage "Cropped and Vulnerable" Map



2.3.3 Third-Stage Sample Selection

In addition to defining the cropped and vulnerable parts of each county, EPA also determined the boundaries of all urban parts of each of the 90 counties. Two types of urban areas were defined from the 1980 census. Any incorporated community of 2,500 or more people was considered urban. The U.S. Bureau of the Census also defines "urbanized areas" as the densely populated region stretching out from urban areas. Those parts of a county that were neither designated as "urban areas" or "urbanized areas" were designated as rural and contain all wells eligible for inclusion in the NPS.

Once these "urban"/"rural" boundaries were determined, recognizable landmarks were identified that best matched these boundaries. This was accomplished by combining information from census maps, county maps of all kinds, zip code atlases, and post offices, and then overlaying this information on the cropped and vulnerable maps.

In the third stage, NPS contractor staff conducted telephone screening interviews with households in the Survey counties. The households were contacted through a statistical selection process known as Random Digit Dialing (RDD) in which clusters of telephone numbers are defined and calls are made randomly to numbers within the cluster. The telephone screening interview determined eligibility by inquiring if the potential respondent lived in a rural area and had a private drinking water well, and was willing to participate. The RDD screener also asked a series of geographic location questions to determine in which second-stage stratum the respondent resided. In order to oversample areas defined as "cropped and vulnerable," only one-third of all eligible well owners in the second stratum (i.e., not "cropped and vulnerable") were selected. The results of the sample selection are described in Exhibit 2-10.

Finally, during the course of the Survey in August 1989, the sample size of the remaining counties in each stratum was increased by one well to account for cancellations and refusals to participate and the inability to sample wells prior to the point of treatment of the water.

Exhibit 2-10
Domestic Well Sample Selection Results

Stratum	Pesticide Usage	DRASTIC Score	Design Sample Size*
1	High	High	91
2	High	Medium	93
3	High	Low	48
4	Medium	High	50
5	Medium	Medium	72
6	Medium	Low	31
7	Low	High	77
8	Low	Medium	112
9	Low	Low	53
10	Uncommon	High	67
11	Uncommon	Medium	88
12	Uncommon	Low	45
			827

* Number of wells selected, including allowances for cancellations, refusals to participate, and inability to sample prior to treatment. Minimum desired sample size after dropout was 734.

Chapter Three: Implementation of the Survey

Introduction

From April 1988 through February 1990, NPS staff collected water samples and data from 566 community water systems and 783 rural domestic wells with the cooperation of Federal, State, and local officials and private citizens. This chapter describes the roles of key project participants who assisted in implementing the Survey and provides an overview of Survey implementation activities. It describes the NPS staff training program, scheduling requirements, water sampling techniques and procedures, and the administration of questionnaires developed for the Survey. Water sampling and data collection were supported by an extensive network of operations management, data management, and communications systems used to plan, organize, perform, and track NPS implementation activities. The roles of these systems in implementing the NPS also are described in this chapter. Appendix C provides additional details and expanded discussions of these topics.

3.1 Key Participants

The National Pesticide Survey was carried out by hundreds of EPA, State, and contractor personnel with the cooperation of county officials, community water system owners/operators, and private citizens who rely on domestic wells for their drinking water. Many of these participants, who came from every State, were volunteers. The roles of key project participants are described below:

- **EPA Headquarters.** EPA NPS staff in Washington, D.C. directed all Survey design and implementation activities. As the focal point of all activities, the NPS Director was responsible for overseeing all Survey activities and facilitating communication among the various NPS participants.

- **EPA Laboratories.** Two EPA laboratories (EPA/Environmental Chemistry Section and EPA/Technical Support Division) participated in the survey design, were responsible for managing analytic methods development, managed contracts for analytical work, reviewed laboratory operations, and performed referee analyses using the appropriate analytical methods. A third EPA laboratory (EPA/Risk Reduction Engineering) performed chemical analyses.

- **EPA Regional Offices.** EPA Regional staff conducted sampling in some States for the CWS program and assisted in communicating information to other Regional personnel, State participants, other State agencies, county officials, the public, and the media.

- **State Personnel.** State participants conducted CWS sampling and data collection activities, participated in the design of survey outreach activities, assisted EPA in distributing sampling results to CWS owners/operators and domestic well owners/residents, and coordinated participation by county officials.

- **County Personnel.** County agriculture extension agents provided information about local soils, hydrogeologic characteristics, and agricultural practices, such as pesticide usage and cropping. County health and law enforcement officials assisted in facilitating Survey participation by responding to public inquiries about the Survey and ensuring citizens that the NPS was a bona-fide project of the U.S. EPA.

- **CWS Owners/Operators.** CWS owners/operators provided additional data about well construction and non-farm and farm pesticide usage on the well property to NPS State sampling teams who collected drinking water well samples and conducted interviews to collect additional data.

- **Rural Domestic Well Owners, Residents, and Farmers.** Private citizens throughout the country voluntarily participated in the Survey by allowing EPA to sample their drinking water wells and answering Survey questions.

- **Implementation and Laboratory Contractors.** Contractors assisted EPA in designing and implementing the Survey, performed chemical analyses of well water samples, and managed day-to-day NPS activities. Research Triangle Institute assisted in the design of the Survey and conducted the pilot survey. ICF Incorporated provided support to EPA by assisting in designing the Survey, and implementing all aspects of the NPS (questionnaire design, staff training, water sampling and data collection, communications, operations management, database management, and data analysis and reporting). Westat Incorporated, ICF's subcontractor, assisted EPA in designing the Survey, selecting the samples of rural domestic wells and CWS wells, and developing the NPS questionnaires. Westat also designed and conducted NPS staff training on questionnaires, conducted domestic well interviews with well owners, residents and farmers, and compiled questionnaire data. Technology Applications Incorporated was responsible for overall quality assurance/quality control coordination and assessment during the Survey. Stretton Associates assisted with communications and reporting. Five private contract laboratories (James Montgomery Laboratories, Alliance Technologies/Clean Harbors Analytical Services, Radian Incorporated, Environmental Science and Engineering Incorporated, and Battelle Columbus Division Laboratory) were responsible for conducting chemical analyses of the drinking water samples.

3.2 Water Sampling and Data Collection

The two major components of Survey implementation were:

1. obtaining water samples from the selected wells to identify the amounts of possible pesticide and nitrate concentrations; and

2. collecting key information through questionnaires and field documentation, to obtain data on additional factors (i.e., well construction and non-farm and farm pesticide usage on the well property, cropping activities, and industry locations in proximity to the well site) potentially affecting pesticides and nitrate concentrations.

NPS water sampling and data collection protocols involved precise methods and procedures. Sample preparation and collection techniques and handling procedures were conducted in accordance with strict procedures and techniques and a specific schedule to ensure that samples were collected and analyzed within quality control (QC) limits. To ensure adherence to these NPS-designed requirements and procedures, EPA developed a training program to provide NPS sampling team personnel with the knowledge and skills necessary to perform water sampling and data collection activities and to ensure that standard methods and procedures were applied for all sampling activities.

3.2.1 NPS Training Program

The NPS training staff conducted 54 CWS training courses in 45 States to instruct EPA and State personnel in CWS sampling and interviewing protocols. For rural domestic well sampling, 11 training courses were held to instruct 30 regionally-based NPS contractor personnel on sampling protocols; three training interviewing methods. NPS training workshops were held from May 1988 until April 1989; refresher training courses were held until January 1990.

The NPS training program oriented CWS State sampling teams and rural domestic well contractor sampling teams in all aspects of NPS sampling, questionnaire administration, and communications in advance of conducting field sampling activities. The training program emphasized the following elements of NPS sampling and data collection:

- NPS scheduling and operations management procedures;
- Unique NPS water sampling and data collection requirements, techniques, methods, and procedures, including hands-on exercises to practice techniques;
- Quality assurance/quality control procedures; and
- NPS communications protocols.

The NPS training program included three units:

1. **Sampling Techniques and Procedures.** Trainees learned proper sampling techniques and procedures for all sampling collection activities, from preparatory requirements conducted prior to field sampling to activities performed after well samples were collected.

2. **Questionnaire Administration.** State personnel learned interviewing techniques and became familiar with the questionnaire contents and proper use of the data collection forms. State personnel learned how to interview community water system owners/operators and county agricultural extension agents; contractor staff learned to use the rural domestic well questionnaires to interview private well owners/residents, farmers, and county agricultural extension agents. State and contractor personnel both participated in role playing exercises to practice the administration of questionnaires.

3. **Communications Protocols.** Survey personnel learned effective communications practices to ensure that the confidentiality rights of private citizens who agreed to participate in the Survey were honored, support the consistency and quality of the Survey results, uphold high Survey participation rates, and develop a positive public perception of EPA and the NPS. Survey personnel participated in role playing exercises to practice responding to citizens' questions in non-technical language and to become conditioned to expecting unanticipated circumstances.

3.2.2 Sampling and Data Collection Scheduling

During the period of sampling and data collection, from April 1988 through February 1990, State and contractor NPS sampling teams collected drinking water samples from 566 community water system wells and 783 rural domestic wells. In addition, they gathered relevant data by interviewing county agricultural extension agents, CWS owners or operators and rural domestic well owners, residents and farmers.

Water sampling of community water systems and domestic wells was scheduled in two-week periods over the entire two-year implementation phase of the Survey. NPS scheduling accounted for the laboratories' capacity to analyze the drinking water well samples and the availability of staff and resources to carry out the sampling and data collection activities.

3.2.3 CWS Well Sampling

CWS samplers were assigned a two-week period from July 1988 through December 1989 in which to conduct field sampling activities for each community water system well site. State CWS sampling teams selected specific sampling dates that were convenient for CWS owners/operators within this two-week sampling period. The NPS Communications Manager and NPS Sample Kit Preparation staff closely monitored the actual sampling date to ensure that sample and data collection activities were conducted as scheduled. A limited number of CWS scheduled sampling dates were revised to accommodate State sampling teams' scheduling conflicts and logistical and budgetary constraints.

3.2.4 Rural Domestic Well Sampling

Rural domestic well sampling also was carried out in scheduled two-week intervals from April 1988 through February 1990. After a two-week period was randomly selected for sampling in a particular county, the NPS contractor screened randomly selected households by telephone to select a representative sample of eligible rural domestic wells. Whenever practical, field sampling and interviewing appointments were scheduled during the screening interview. Non-resident well owners and farmers of the property where the well was located, who were identified during the screening interview, were also contacted to schedule separate interviews during the two-week sampling period. The NPS communications staff recontacted domestic well owners/residents by mail and telephone to provide them with additional information and answer questions about the Survey, schedule and confirm sampling dates, and determine detailed directions for traveling to the well location.

The NPS Communications Manager tracked all sampling schedules to ensure that rural domestic well sampling was conducted during the scheduled two-week sampling period. The NPS communications staff completed sampling schedules for domestic well sampling teams, providing them with resident/owner names and phone numbers, sampling dates and times, directions to well sites, and interview dates and times. Any schedule changes reported from sampling teams in the field were carefully documented and scheduling adjustments were made when practical.

During interviews additional farmers and non-resident well owners were sometimes identified. Field teams would then contact these people and schedule interviews to obtain additional information concerning the well and activities on the land surrounding the well.

The NPS field supervisor contacted county agricultural extension agents in advance of the two-week sampling period and scheduled a time for interviewing. Field interviewers then interviewed the county agricultural extension agent and collected information on the area surrounding each sampled well.

3.2.5 Scheduling Database Management

A computerized information management system, the National Pesticide Survey Information System (NPSIS), was developed to monitor and track the CWS and domestic well sampling operations. NPSIS generated tracking reports that documented the designated two-week sampling periods, scheduled sampling dates, and sample receipt dates by NPS laboratories. A more detailed description of NPSIS and the operations management reports it generated is provided in the Database Management Section of this chapter and Appendix C.

3.2.6 Sampling and Data Collection Techniques and Procedures

All CWS and rural domestic well sampling activities were carried out using standard operating procedures (SOPs), including quality assurance/quality control (QA/QC) checks, developed for the NPS. The standard steps to conduct field sampling included collection of well water; completion of questionnaires and other records to obtain supporting data; and sample collection follow-up activities, including shipment of samples to laboratories and the completion and return of sampling logs, records, and questionnaires. These steps are described below.

Sample Collection

- **Approval for Sampling.** Upon arrival of the sampling team at a well site, the Field Team Leader briefly described the sampling process to the well owner, obtained written permission to sample from private well owners or residents, and inquired about water treatment and the location of the well tap.

- **Sample Collection Procedures.** Sample kits were prepared in advance to ensure that all sample collection materials were on hand. Sample collection procedures included measuring air temperature near the well tap; purging the well until temperature, conductivity, and pH of the well water were stabilized to ensure that fresh ground water was being sampled; and filling sample bottles with well water. Each sample was iced immediately after being taken and placed in an insulated cooler for shipment to the analytic laboratories. NPS sampling teams collected at least 17 water samples at each well site to allow one sample plus one backup for each of the eight analytical methods. Additional samples were taken, as required, for sample stability studies. Additional samples were taken from 5 to 10 percent of all wells sampled for QA/QC review by two EPA laboratories, as described in Chapter 5.

- **Recordkeeping.** Sampling team members recorded the date, time, and sampler's initials on all sample bottles, and the team leader reviewed the Sample Tracking Form (see Appendix C) to ensure that all samples were collected and to begin sample tracking. The team leader also completed the Well Observation Record (see Appendix D) to collect information regarding the well area, including topography, soils, water treatment and storage systems, well housing, and additional observations deemed noteworthy because of their potential influence on pesticide migration to the well being sampled. The team leader also prepared well-specific notes, including a sketch of the well system indicating the sampling port or tap and a sketch of local land features around the well, in the Well Observation Record.

Data Collection

- **Questionnaire Administration.** The Survey research team member interviewed the CWS well owner or operator, the rural domestic well owner, resident, and farmers when appropriate and the county agriculture extension agent to collect information about well construction, non-farm and farm pesticide usage on the well property, cropping activities, and industry locations in proximity to the well site.

3.2.7 Activities Following Sample Collection

The sampling team completed a Field Logbook for each well site. The logbook included a Final Domestic Well Checklist and a Well Sampling Information Sheet to document well location, well owner/operator identification, sample kit identification, sampling date, shipment information, and the responsible sampling team leader.

The sampling team shipped sample kits by express, overnight delivery to designated laboratories. The sampling team also shipped completed questionnaires, sample tracking forms, airbills, and field logbooks to NPS contractor staff, and reported shipment of water samples and field documentation via the NPS Hotline.

3.3 Questionnaires

NPS questionnaires were developed to collect data necessary for the interpretation of NPS analytical results. (The NPS questionnaires are provided in Appendix D; a brief description of the NPS questionnaires is provided in Exhibit 3-1.) Questionnaires were administered by the NPS to determine whether randomly selected community water systems and domestic wells were eligible for NPS water sampling; record observations about the well location and the surrounding area; collect information from the owner/operator about the use and construction of the well sampled and use of non-farm and farm pesticides (e.g., volume of and location of application in relation to the well) on the property where the well was located; and gather information from local area experts about cropping, pesticide use, and industry locations within one-half mile of the well.

Questionnaires were administered by NPS State, Region, or contractor sampling team personnel for the CWS program, and by survey research contractors for the domestic well program. As part of both the CWS and domestic well sampling collection activities, sampling team personnel administered two questionnaires to the well owner/operator and another questionnaire to the local county agricultural extension agent. If the domestic well owner or farmer(s) were different from the resident, each was interviewed using the appropriate part of the questionnaires. NPS staff trained and periodically audited team leaders to ensure that they were accurately recording field responses. Information gathered during these interviews was merged with the analytical results to provide a data base for relational analyses.

3.3.1 Incorrect or Missing Data Items

Incomplete or incorrect information occurred in questionnaires either because a field interviewer failed to record a response where one should have been recorded or because the recorded responses failed a quality control check. NPS survey research staff instituted data retrieval efforts and imputation procedures to account for incomplete or incorrect questionnaire items. NPS staff made follow-up calls to questionnaire respondents to complete certain missing information or to confirm questionnaire responses identified as questionable by range or logic checks.

3.4 Survey Operations Management

An extensive operations management system monitored field activities and maintained accurate records of sampling and data collection activities. Operations management included determining the equipment and supply needs of the Survey, establishing systems for tracking the inventory of supplies and equipment, conducting logistics operations to support well sampling, mailing and tracking questionnaires, and planning and processing travel arrangements for interviewers.

3.4.1 Equipment and Supplies

The NPS required large amounts of equipment and supplies to obtain and transport thousands of water samples from over 1,300 wells. Equipment needs were projected at the beginning of the Survey and adjusted, based on actual field sampling experience and to account for modifications in the number of wells being sampled. NPS staff developed custom-made styrofoam water sample container kits to facilitate sample handling and minimize bottle breakage. It was necessary to design and prepare custom-made sample kits because commercially available coolers did not meet NPS sample bottle dimension specifications. The NPSIS Equipment Tracking System was developed to monitor the inventory of equipment supply kits: temperature, conductivity, and pH meters, and other field sampling tools and track equipment damage.

Exhibit 3-1
National Pesticide Survey Questionnaires

The *Screening Survey Questionnaires* were developed to identify a national sample of both community water systems and domestic wells that met specific NPS eligibility criteria. NPS survey research contractors conducted the CWS and domestic well screening interviews by telephone. The domestic well questionnaire was administered using Computer Assisted Telephone Interviews (CATI), which automatically tracked the questions as responses were entered, reducing the incidence of mis-keyed information, and used the correct unique set of geographic location questions for each county.

The sampling team leader completed the *Team Leader Introduction and Well Observation Record* by interviewing the respondent and recording on-site observations about the well and the surrounding area, deemed important because of their potential influence on pesticide contaminant migration into the sampled well.

The *CWS and Domestic Well Main Questionnaires* collected information regarding water use, water treatment, well construction, and non-farm and farm pesticide usage on the property where the well is located. Trained EPA Regional and State sampling team personnel conducted the CWS interviews at the time of sampling; trained survey research contractors administered the domestic well questionnaire on-site at the time of sampling.

The *Domestic Well Second-Stage County Agent Questionnaire* gathered cropping and pesticide use information to determine what pesticides were used within the county for relational analyses. Agricultural specialists, trained in administering the County Agent Questionnaire, conducted the second-stage county agent interviews on-site. If necessary, NPS staff conducted follow-up phone interviews, within one month of completing each County Agent Questionnaire, to obtain any missing information.

The *Local Area Expert Questionnaire* was used to obtain additional information about local conditions and usage of land and pesticides within one-half mile of the well. Trained CWS EPA Regional and State sampling team personnel and domestic well research contractors interviewed local area experts at the time of sampling.

3.4.2 NPS Sampling Kit Preperation

All NPS water sampling kits were distributed from the NPS Preparation Room, located in the office building of the implementation contractor in Fairfax, Virginia. NPS staff followed standard operating procedures for preparing water sampling kits and tracking the shipment of water sampling kits to field sampling teams and laboratories. A color coded system was developed to categorize the sample kits for the contract laboratories and EPA referee laboratories.

An equipment kit, with an assigned serial number, was prepared for each well site, containing tools and equipment required for sampling in the field. The appropriate sampling forms and bottles were placed in sample kit containers according to the particular sampling scenario that was anticipated. The Preparation Room Manager ensured that the standards for meter calibration were maintained, including keeping accurate records of all completed calibrations.

Preparation Room personnel also prepared a Field Logbook for each CWS and rural domestic well site sampled and shipped logbooks to the sampling teams approximately five weeks prior to the scheduled sampling date.

Sampling teams shipped their completed sample kits to the NPS laboratories via express, overnight delivery so that sample holding time requirements were observed. NPS laboratories returned used sample kits, so that the kits (but not sample bottles) could be recycled for future use.

3.4.3 Mailing and Tracking Questionnaires

Questionnaires were mailed to NPS field staff for each well to be sampled. The status of each questionnaire as it was mailed, received, and processed was recorded in separate CWS and rural domestic well receipt control/tracking systems. For community well systems, the questionnaires were mailed first to the NPS Preparation Room, where they were included with the field log books and then mailed to the field team leader. Upon completion of all three field instruments, the field team leader would then return the questionnaires with the log book.

For rural domestic wells, questionnaires for all wells in a county were mailed together to the field interviewer. Upon completing all forms for a county, the interviewer mailed the entire set to the contractor for processing.

3.5 Data Management

3.5.1 NPSIS

The National Pesticide Survey Information System (NPSIS) was designed to serve as a computerized management information system for all aspects of the Survey. NPSIS was used to automate NPS sampling implementation and analytical results information, with the exception of questionnaire data management. For sampling implementation operations management, NPSIS was used to generate numerous management reports to develop and monitor sampling schedules; track the preparation, shipment, and receipt of sample kits; record sampling data, including problems encountered; and serve as a communications network between the NPS Prep Room and laboratory staffs.

The objective of the data control methods adopted for the NPS was to collect and store data in an efficient, user-friendly manner, while maintaining high data quality standards. NPSIS data control methods included automating:

- Data entry of Survey results and relevant operating information and manipulation of this data using computers;
- QA/QC checks for data entry via computer software; and
- The backup of computerized data to ensure against loss.

3.5.2 Implementation Database Management

The implementation component of the database management system consisted of the Sampling Control System (SCS), Communications Control System (CCS), Document Control System (DCS), and the NPS Problem File. The functions of each of these database systems are as follows:

- SCS was designed to automate information collection, storage, and retrieval for various sampling tasks;
- CCS was developed and integrated with the SCS to assist the NPS Communications Staff to track DWS sampling schedules, communications information needed to secure voluntary participation from domestic well owners, and participation rates;

- DCS was created to provide an efficient way to store and retrieve project records; and
- The NPS Problem File was produced to document and help resolve problems associated with sampling that could affect the validity of the analytic results.

3.5.3 Analytic Results Data Management

NPSIS was a geographically distributed personal computer network that linked sample delivery with the contract laboratories and EPA laboratories. Using NPSIS, the Preparation Room staff were able to ensure that the appropriate sample container kits arrived in the field on schedule and that all completed field sample bottles were delivered to the designated laboratories in appropriate time and condition (i.e., iced to maintain adequate temperature). NPSIS was used to inform NPS laboratories of anticipated sample arrivals and allowed the laboratories direct computer access, to acknowledge sample and receipt conditions.

Contract laboratories analyzed samples, prepared preliminary analytical results, and submitted data to EPA referee labs. The referee labs performed QA/QC checks. After extensive data review, analytical results for each well were sent to communications staff for distribution to well owners/operators.

3.5.4 Questionnaire Results Data Management

Once questionnaires were returned to the contractor they were coded and data were entered. Missing, out of range, or illogical data were identified (using computerized edits) for data retrieval or imputation, and the revised data were reviewed for compliance with all range, logic, and consistency checks. CWS Team Leader questionnaires underwent an additional initial data retrieval to clarify the identity of the well that was sampled. A computerized tracking system kept track of each questionnaire at every stage. This system was used to identify overdue cases (i.e., questionnaires that had not been returned on schedule), progress of data preparation tasks, and the location of the hard copy of the questionnaires for review, as needed.

3.6 Communications

Communications operations were integral to the success of Survey implementation. The NPS involved participation and cooperation among EPA Headquarters personnel, ten EPA Regional Offices, numerous Federal agencies, State officials in all 50 States, community water system owners/operators and county officials, private citizens, as well as implementation, survey research, and laboratory contractors. The large scale and complex design of the NPS required communications activities that effectively managed information among the many, diverse participants and interested parties throughout the country. This section provides a brief description of NPS communications activities.

3.6.1 Internal Communications Activities

A communications network was established to facilitate the exchange of information between NPS Headquarters in Washington, D.C. and all project participants about sampling schedules, results, and other important information. EPA conducted regular NPS Work Group meetings, weekly staff meetings, monthly conference calls with EPA Regional staff, and periodic meetings with State participants and other State officials and EPA Regional staff in EPA Regional offices, to promote consistent communications among all NPS participants. In addition, EPA established a temporary NPS Hotline -- a toll-free telephone information line -- to facilitate communication among sampling team personnel and Headquarters staff. The hotline was used to solve sampling problems while the sampling team was at the well site and to provide well owners and State participants with easy access to the NPS information. The NPS communications staff operated the hotline and responded to inquiries on Survey activities, including scheduling, field sampling, and the status of well sampling results.

3.6.2 External Communications Activities

EPA kept a variety of interested parties (e.g., well owners, pesticide industry representatives, trade associations, government agencies and associations, county and State officials, and Congressional staff, agricultural groups, environmental and public interest groups, universities and professional associations, and the general public) informed of the NPS survey design, sampling procedures, scheduling, and analytical methods and results. EPA maintained an extensive NPS mailing list and periodically published newsletters, the "NPS Project Update," to keep all interested parties informed of the Survey's progress. The EPA Press Office released press updates to notify the public of current NPS activities. EPA established strict procedures to ensure the proper dissemination of well sampling results. The NPS communications staff notified well owners and State officials of well sampling results by instituting these procedures to ensure that the privacy of domestic well residents/owners was protected and to comply with Freedom of Information Act regulations. Results from the sampling of community water system wells were made public as soon as the State and the CWS had been notified. Sampling results relating to the wells of private individuals were protected to ensure individual privacy, while still permitting disclosure of sampling results. Domestic well sampling records were not accessible by the name or address of any individual but by an anonymous well code. States were asked to provide written statements of their ability to maintain confidentiality. Results of domestic well sampling and other information will be released only in appropriately aggregated form or by anonymous well code.

3.6.3 Implementation Communications Materials

EPA developed and distributed a variety of outreach materials and implemented numerous communications activities to ensure that all NPS participants and interested parties were informed. A description of these materials and activities is provided below.

- **NPS Pamphlets.** EPA developed a CWS pamphlet and a companion rural domestic well pamphlet for CWS owner/operators and owners of domestic wells to provide information about the purpose of the Survey and explain what was required to participate.

- **NPS Project Updates.** EPA published periodic newsletters to inform project participants and interested parties of the progress of the National Pesticide Survey implementation efforts. EPA maintained an extensive NPS mailing list of Regional, State, and county officials, industry representatives, public interest groups, and associations and periodically published the "NPS Project Update" to keep all interested parties informed of the Survey progress.

- **Rural Domestic Well Sampling Team Communications Packets.** NPS communications staff prepared communications packets for contractor sampling teams for each county in which rural domestic wells were sampled. The packets contained NPS pamphlets and updates, the NPS confidentiality policy, a list of appropriate State and EPA contacts, sampling schedules, and permission forms. Rural domestic well sampling teams used these documents to respond to questions from well owners, local citizens and officials, and the media and to provide information to well owners about the purpose of the NPS, sampling procedures, the notification of results, and confidentiality issues.

- **Media Relations.** Pesticide use and ground-water quality have received a great deal of media coverage in the past several years. EPA Headquarter's Press Office issued press advisories and news releases on NPS activities, and EPA Regional contacts responded to local media inquiries.

- **Health Advisories.** EPA developed 99 technical Health Advisories for pesticides and nitrate using information collected on physicochemical properties, uses, chemical fate, health effects, treatment, and existing criteria and guidelines. These Health Advisories are scientific guidance documents that were used to evaluate the results of well sampling and to determine whether the contamination levels found warranted further action.

- **Health Advisory Summaries.** As part of EPA's effort to improve risk communication, the Agency prepared non-technical Health Advisory Summaries explaining the health effects of exposure to pesticides and nitrate in simple language; the summaries were distributed to the owners, residents, and operators of sampled wells where pesticides and nitrate were found.

- **Notification of Results Packets.** EPA established strict procedures to ensure the proper dissemination of well sampling results. The NPS communications staff notified well owners and State officials of well sampling results by instituting these procedures to ensure that the privacy of domestic well owners was protected and to comply with Freedom of Information Act regulations. Owners and residents of all NPS sampled wells in which detections of pesticides and nitrate were found were notified by letter and provided appropriate Health Advisory Summaries and information to assist them in contacting State and county officials for assistance.

3.6.4 NPS Communications Strategy

A communications strategy was prepared in late 1988 to establish communications protocols and provide guidance for communications activities throughout the Survey, from pre-survey development to release of the Phase II Report.

EPA held meetings with key Federal, State, and local agencies to gather input about the Survey design and to promote cooperation from these groups in implementing the Survey. EPA met with the Department of Agriculture (USDA), the Bureau of the Census, and the U.S. Geological Survey (USGS) to discuss the survey design and implementation issues.

The NPS Work Group was established in the fall of 1986 to review NPS project plans, solicit comments and advice from participating members, and establish communications procedures for participating States and counties. The Work Group consisted of EPA Headquarters and Regional staff, State personnel, and other involved persons. The Work Group met periodically to advise on implementation issues such as confidentiality, notification of results, and communication materials. These early coordination efforts were important to the long term success of the Survey.

3.6.5 Release of NPS Results

The following activities are planned to release NPS results to interested parties and the general public.

- **Briefings/Presentations.** EPA Headquarters will conduct briefings for EPA management and Regional EPA offices, other Federal agencies, State officials, and professional and trade associations. Topics include Survey implementation and Survey results.

- **Fact Sheets/Outreach Materials.** EPA has prepared a series of fact sheets and outreach materials to disseminate the background information about the NPS and the findings of the Survey in a concise, easy to understand manner.

- **Dissemination of Materials.** EPA has compiled a contact list from existing NPS and master mailing lists that will be used to distribute copies of the Phase I and Phase II reports and notices of their availability, pamphlets and outreach materials, and press kits.

- **Reports and Information Materials.** A list of key NPS reports, supplemental materials, and other information materials is provided in Exhibit 3-2.

Exhibit 3-2
NPS Reports and Information Materials

Pre-Survey Reports:

Final Report on the Management Systems Review of the Pilot Survey of Pesticide Contamination in Groundwater, 1987, Quality Assurance Management Staff, USEPA.

National Survey of Pesticides in Drinking Water Wells, A Review of the Planning Process and the Data Quality Objectives, 1987, Monica Nees and Cynthia Salmons, RTI/7801/06/01F.

National Pesticide Survey Data Quality Objectives, 1988, ICF Incorporated.

National Pesticide Survey Pilot Study Evaluation Summary Report, 1987, Office of Drinking Water and Office of Pesticide Programs, USEPA.

National Pesticide Survey Pilot Evaluation Technical Report, 1987, R.E. Mason, L.L. Piper, W.J. Alexander, R.W. Pratt, S.K. Liddle, J.T. Lessler, M.C. Ganley, D.J. Munch, and G. Langner, RTI/7801/06-02F.

National Pesticide Survey Communications Strategy, 1988, ICF Incorporated.

Ground-water Vulnerability Assessment In Support Of The First Stage Of The National Pesticide Survey, 1988, W.J. Alexander, S.K. Liddle, R.E. Mason, and W.B. Yeager, RTI.

National Survey Of Pesticide Residues In Community System And Rural Domestic Wells Sample Allocation Report, 1988, R.E. Mason and R.M. Lucas, RTI/7801/04-04F.

Scientific Advisory Panel Reports:

Technical Review of the Preliminary Design of the National Survey of Pesticides in Ground Water – Report of Subpanel Recommendations, October 9, 1985, Federal Insecticide, Fungicide, and Rodenticide Act Scientific Advisory Panel Subpanel.

A Set of Scientific Issues Being Considered by the Agency in Connection with the National Pesticide Survey Pilot Study, October 9, 1987, Federal Insecticide, Fungicide, and Rodenticide Act, Scientific Advisory Panel Subpanel.

Quality Assurance Project Plans:

The National Survey of Pesticides in Drinking Water Wells Quality Assurance Project Plan for the Pilot Study, 1987, Shri Kulkarni, Frank Smith, Cindi Salmons, and Susan Coffey, RTI/7801/06/01.

Final Quality Assurance Project Plans are listed in Exhibit 5-2.

Project Updates

Health Advisories

Health Advisory Summaries

NPS Fact Sheets

Brochures

Chapter Four: Analytical Chemistry

Introduction

This chapter describes how EPA chose the pesticides and pesticide degradates (the analytes) to be tested for in NPS well water samples. It identifies and describes the development of the testing methods that were used. Finally, it identifies and describes the activities of the analytical laboratories that conducted the testing.

4.1 Analyte Selection and Methods Development

Preliminary development of a list of potential analytes for the NPS began in 1984, when an NPS Analyte Selection Task Group was formed. The Task Group was composed of EPA personnel from the Office of Pesticide Programs and Office of Drinking Water.

The Task Group began with a list of approximately 600 pesticide active ingredients. From that list, the Task Group identified pesticides and pesticide degradates as potential Survey analytes by choosing those compounds that met several criteria. First, pesticides and pesticide degradates previously detected in ground water, as well as pesticides regulated under the Safe Drinking Water Act, were automatically included in the list of potential Survey analytes. In addition, pesticides and pesticide degradates were included if:

- the pesticide's chemical/physical parameters, including water solubility, partition coefficients, field half-life, hydrolysis half-life, and others, indicated a potential to leach to ground water; and

- at least one million pounds of the pesticide were estimated to have been used nationwide in 1982.

By October 1986 a list of 100 pesticides and pesticide degradates was identified as potential NPS analytes. Additional analytes were added to this list based on the studies of analytic methods conducted simultaneously with analyte selection. The additional analytes were chemicals that the NPS methods would identify and quantify for little or no added expense while the multi-residue analyses were being carried out. Ultimately, 127 analytes were chosen. Detailed information about the NPS analytes is provided in Exhibit E-1 in Appendix E.

Work to identify appropriate analytical methods began with the development of the first list of potential analytes in mid 1984. An NPS Analytical Methods Task Group identified analytic methods through literature searches, consultations with pesticide analysis experts, and laboratory testing of methods.

An important goal was identifying or developing analytic methods that could identify more than one analyte ("multi-residue methods") so that a small number of methods covered as many pesticides as possible. Whenever a published analytical method was not available for a potential analyte, the importance of developing such a method was evaluated, based on the importance of the pesticide and the cost and time necessary to develop an analytic method. Research into multi-residue analytic methods for NPS analytes was begun in early 1985 at the Battelle Laboratories, Columbus Division, under the joint direction of the Technical Support Division of ODW and the Environmental Monitoring and Systems Laboratory - Cincinnati. Reviews of the available literature indicated that analytical procedures existed for most of the analytes of particular interest to EPA. However, these methods varied widely in procedure and application, and were applicable to single analytes. The primary goal of the methods development study therefore was the consolidation of these many analytical procedures into a smaller group of methods capable of evaluating multiple analytes. Efforts were directed towards retaining the proven aspects of previously published methods, while developing the procedures necessary to ensure the quality of the analyses. In this manner, the original published methods were transformed into methods amenable to use in the NPS as well as in future analysis of pesticides in water. The major work of determining proper sample preparation, separation, and detection techniques was accomplished during the course of 1985, but continued up to the beginning of implementation of the full Survey.

Six new multi-residue analytic methods were developed for the Survey (Methods No. 1-6). In addition, two existing EPA methods (No. 7 and 9) also were used. One method (No. 8), for volatile organic compounds, was dropped after extensive evaluation because of problems with sample aeration under Survey conditions and because of cost considerations. These methods are described briefly in Exhibit 4-1.

4.2 Analytical Laboratories

The chemical analyses of NPS water samples were performed at five contract laboratories and three EPA laboratories.[4] The contract laboratories were responsible for analyzing water samples collected at all of the field sites by one or more analytic methods. In addition, analytical precision and accuracy and analyte stability determinations were made using laboratory spiked well water and reagent water samples analyzed at the contract laboratories. The EPA laboratories analyzed duplicate water samples collected at 5 to 10 percent of the field sites (the rate varied with each NPS method) as one measure of the quality of the analyses being performed at the primary laboratories, and provided back-up capacity. (See Sections 4.4 and 4.5 for additional information on this topic.)

Personnel at the EPA laboratories were responsible for the technical and contractual management of the contract laboratories and for performing referee analyses of duplicate water samples using the appropriate analytical methods. Exhibit 4-2 identifies the contract and EPA laboratories and the analytic methods performed at each laboratory.

4.3 Minimum Quantification and Reporting Limits

The NPS analytic methods were designed to identify both the presence and concentration of analytes in water samples, whenever possible. For 112 of the 127 analytes, minimum reporting limits were established, above which the analyte was reported as having been detected; in addition, minimum quantification limits were established above which the concentration as well as the detection was reported. For 15 analytes which were either unstable or lacked reliable method performance, no reporting limit was established. The presence of these analytes is reported as a "positive detection" without quantification. Exhibit 4-3, which identifies the analytic method for each analyte, also indicates which analytes did not have quantification limits.

The minimum quantification limit (MQL) was established through a two-step process. First, an estimated detection limit (EDL, i.e., the minimum concentration of the analyte that can be measured and reported with confidence that the analyte concentration is greater than zero as determined from the analysis of a sample in a given matrix containing the analyte) was determined for each analyte. The EDL was calculated from results of seven or more replicate analyses of a reagent water sample fortified with the concentration of the analyte that would yield a chromatographic peak with a signal to noise ratio of approximately five to one. The standard deviation of these data was then multiplied by the students' t value appropriate for a 99 percent confidence level and a standard deviation estimate with n-1 degrees of freedom where n equalled the number of replicate analyses. The EDL was defined as either this calculated concentration or the concentration of analyte yielding a five to one signal to noise ratio, whichever was greater.

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[4] The EPA Environmental Chemistry Section and the EPA Technical Support Division also managed the contracts with other laboratories for analytical services. Method 9 was performed by the Risk Reduction Engineering Laboratory, Office of Research and Development, U.S. EPA, 26 W. Martin Luther King Drive, Cincinnati, Ohio, but this EPA laboratory did not manage contract laboratories.

Exhibit 4-1
NPS Analytic Methods

Method Number	Analytes	Number of Analytes	Method
NPS #1* (EPA #507)**	Nitrogen-Phosphorous containing Pesticides	46	Gas Chromatography with a Nitrogen-Phosphorous Detector
NPS #2* (EPA #508)	Chlorinated Pesticides	29	Gas Chromatography with an Electron Capture Detector
NPS #3* (EPA #515.1)	Chlorinated Acid Pesticides	17	Gas Chromatography with an Electron Capture Detector
NPS #4*	Pesticides and Pesticide Degradates (Carbonates and related compounds)	18	High Performance Liquid Chromatography with an Ultraviolet Detector
NPS #5* (EPA #531.1)	N-methyl Carbamoyloximes and N-methyl Carbamates	10	Direct Aqueous Injection HPLC with Post-Column Derivatization
NPS #6*	Ethylene thiourea	1	Gas Chromatography with a Nitrogen-Phosphorous Detector
NPS #7 (EPA #504)	1,2 - dichloropropane; Dibromochloropropane (DBPC); Ethylene dibromide (EDB); cis - 1,3 - dichloropropene; trans - 1,3 - dichloropropene	5	Microextraction and Gas Chromatography
NPS #8*** (EPA #524)	—	—	—
NPS #9 (EPA #353.2)	Nitrate/Nitrite	1	Automated Cadmium Reduction and Colorimetric Detection
		Total 127	

* New method developed for NPS.

** The EPA method listed (e.g., "EPA #507") is the NPS method adopted by EPA as an official Agency method and currently referenced under the designated number. For details on each NPS Method, see the Quality Assurance Project Plans listed in Exhibit 5-2 in the following chapter.

*** Method #8 (EPA Method #524 for volatile halogenated, aromatic, and unsaturated organic compounds in water by purge and trap gas chromatography) was initially considered and evaluated for use but was dropped.

Exhibit 4-2
NPS Contract Laboratories and EPA Laboratories for the Full Survey

Contract Laboratories	Methods
James Montgomery Laboratories 555 East Walnut Street Pasadena, California 91109	1, 3, 9
Alliance Technologies/Clean Harbors Analytical Services 213 Burlington Road Bedford, Massachusetts 01730	2
Radian, Inc. 8501 Mo-Pac Boulevard Austin, Texas 78766	4
Environmental Science and Engineering, Inc. 14220 West Newbury Road Gainesville, Florida 32607	5, 7
Battelle Columbus Division 505 King Avenue Columbus, Ohio 43201	6

EPA Laboratories	Methods
Environmental Chemistry Section Office of Pesticide Programs U.S. EPA Stennis Space Center Bay St. Louis, Mississippi 39529-6000	1, 3, 6
Technical Support Division Office of Drinking Water U.S. EPA 26 West Martin Luther King Drive Cincinnati, Ohio 45268	2, 4, 5, 7, 9
Risk Reduction Engineering Laboratory Office of Research & Development U.S. EPA 26 West Martin Luther King Drive Cincinnati, Ohio 45268	9

Exhibit 4-3
Survey Analytes and Analytic Methods

NPS METHOD 1: Gas Chromatography with a Nitrogen-Phosphorous Detector (46 Analytes)

- Alachlor
- Ametryn
- Atraton
- Atrazine
- Bromacil
- Butachlor
- Butylate
- Carboxin
- Chlorpropham
- Cycloate
- Diazinon*
- Dichlorvos
- Diphenamid
- Disulfoton*
- Disulfoton sulfone*
- Disulfoton sulfoxide*
- EPTC
- Ethoprop
- Fenamiphos
- Fenarimol
- Fluridone
- Hexazinone
- MGK 264
- Merphos*
- Methyl paraoxon
- Metolachlor
- Metribuzin
- Mevinphos
- Molinate
- Napropamide
- Norflurazon
- Pebulate
- Prometon
- Prometryn
- Pronamide*
- Propazine
- Simazine
- Simetryn
- Stirofos
- Tebuthiuron
- Terbacil
- Terbufos*
- Terbutryn
- Triademefon
- Tricyclazole
- Vernolate

NPS METHOD 2: Gas Chromatography with an Electron Capture Detector (29 Analytes)

- 4,4-DDD
- 4,4-DDE
- 4,4-DDT
- Aldrin
- Chlorobenzilate*
- Chloroneb
- Chlorothalonil
- DCPA
- Dieldrin
- Endosulfan I
- Endosulfan II
- Endosulfan sulfate
- Endrin
- Endrin aldehyde
- Etridiazole
- Heptachlor
- Heptachlor epoxide
- Hexachlorobenzene
- Methoxychlor
- Propachlor
- Trifluralin
- alpha - HCH
- beta - HCH
- delta - HCH*
- gamma - HCH
- alpha-Chlordane
- gamma-Chlordane
- cis - Permethrin
- trans - Permethrin

NPS METHOD 3: Gas Chromatography with an Electron Capture Detector (17 Analytes)

- 2,4-D
- 2,4-DB
- 2,4,5-TP
- 2,4,5-T
- 3,5-Dichlorobenzoic acid
- 4-Nitrophenol*
- Acifluorfen*
- Bentazon
- Chloramben*
- DCPA acid metabolites
- Dalapon*
- Dicamba
- Dicamba, 5-hydroxy-
- Dichlorprop
- Dinoseb
- Pentachlorophenol (PCP)
- Picloram

NPS METHOD 4: High Performance Liquid Chromatography with an Ultraviolet Detector (18 Analytes)

- Atrazine, deethylated
- Barban
- Carbofuran, phenol-3-keto-
- Carbofuran, phenol
- Cyanazine
- Diuron
- Fenamiphos sulfone
- Fenamiphos sulfoxide
- Fluometuron
- Linuron
- Metribuzin DA
- Metribuzin DADK*
- Metribuzin DK*
- Neburon
- Pronamide metabolite
- Propanil
- Propham
- Swep

NPS METHOD 5: Direct Aqueous Injection HPLC with Post-Column Derivatization (10 Analytes)

- Aldicarb
- Aldicarb sulfone
- Aldicarb sulfoxide
- Baygon
- Carbaryl
- Carbofuran
- Carbofuran, 3-hydroxy-
- Methiocarb
- Methomyl
- Oxamyl

NPS METHOD 6: Gas Chromatography with a Nitrogen-Phosphorous Detector (1 Analyte)

- Ethylene thiourea ([illegible])

NPS METHOD 7: [illegible] and Gas Chromatography (5 Analytes;

- Ethylene dibromide ([illegible])
- Dibromochloropropane (DBCP)
- 1,2 - dichloropropane**
- cis - 1,3 - dichloropropene**
- trans - 1,3 - dichloropropene**

NPS METHOD 9: Automated Cadmium Reduction and Colorimetric Detection (1 Analyte)

- Nitrate and nitrite measured as nitrogen (N)

* Qualitative only.

** Method 8 dropped. Analytes previously included in Method 8 also detectable by Method 7.

This procedure was an adaptation of EPA's existing minimum detection limit procedure. [Glaser, et al., "Trace Analysis for Waste Waters," 15 Environmental Science and Technology 1426 (1981)].

The MQL then was determined by multiplying the EDL by a factor, based on the best professional judgment of the EPA referee laboratory staff, determined in part by the degree to which the method is subject to interferences. The factors were: Method #1 = 4, Methods #2-4 = 5, and Methods #5-7 and 9 = 3. The purpose of this step was to determine a MQL that could be reasonably maintained throughout the course of the Survey and take into account day-to-day variations. The MQLs for each analyte are provided in Appendix E, Exhibit E-2.

The minimum reporting limit (MRL) was based on the MQL. Analytes detected above the MQL were reported with quantification (i.e., at a specified concentration). Analytes detected at a concentration that was estimated to be between one-half the established MQL and the MQL were reported as detected without quantification, in order to maximize the sensitivity of the methods while maintaining reasonable minimum reporting and quantification limits. EPA chose relatively stringent reporting limits. If the reporting limits used in the NPS had been consistently lower, the number of reported detections might have been higher, but such lower limits would be reflected in less confidence in the analytic results.

4.4 Confirmation of Positive Detections

The identity and concentration of all pesticide and pesticide-related analytes detected was confirmed with a second, separate analysis on another chromatographic column. It was not necessary to confirm detections of nitrate because of the extremely specific nature of the analysis.

The primary laboratories confirmed detections by reanalyzing all suspected positive extracts using a second (different) capillary gas chromatographic (GC) column (Methods 1, 2, 3, 6, and 7) or a different quantitative and qualitative high performance liquid chromatographic (HPLC) column (Methods 4 and 5). These analyses provided both a preliminary qualitative confirmation for all GC determinations and the final confirmation for HPLC analyses. The analytes detected using a GC-based method also were qualitatively confirmed using gas chromatography/mass spectrometry (GC/MS).

Quantitative results were reported, if the concentration determined on the confirmational column agreed within 25 percent of that determined on the primary column. If this requirement was met, the quantitative results determined on the primary column were reported. If this requirement was not met, and for analytes determined using a GC method, the presence of the analyte was confirmed by GC/MS, and the detection of the analyte was reported without quantification.

4.5 Quality Control

To ensure the accuracy of calibration standards, verified 1-2 mg/mL stock standards (solutions containing a standard that is a method analyte obtained from and certified by EPA's Pesticide and Industrial Chemicals Repository) were provided in sealed glass ampules to all of the participating laboratories. These standards were prepared by The Bionetics Corporation in Cincinnati, Ohio and verified by the EPA referee laboratories prior to distribution to the primary laboratories.

A number of quality control procedures were implemented for all analyses. Control charts were maintained tracking the recovery of laboratory control standards and surrogate standards. Quality control measures included but were not limited to the use of the following:

- Laboratory Control Standards (a solution of analytes prepared in the laboratory by dissolving known amounts of pure analytes in a known amount of reagent water) to ensure that the extraction processes maintained consistent analyte recovery (Methods 1-6);

- Instrument Control Standards (Methods 1-6) (a solution containing specified concentrations of specified analytes that is analyzed each working day prior to the analysis of sample extracts) to ensure that analytical instrumentation was properly calibrated and performing properly prior to sample analysis;

- Surrogate Standards (Methods 1-7) (pure compounds that are not sample components added to a sample in a known amount and used to detect gross abnormalities during sample preparation) to demonstrate proper analyte recovery in individual samples; and

- Method Blanks (a portion of reagent water analyzed as if it were a water sample) (Methods 1-7 and 9) and Shipping Blanks (reagent water shipped to the field and returned to the lab with the samples) (Method 7) were analyzed to help control false positives.

In addition to the quality control procedures employed in the laboratories, a series of quality control measures, detailed in Chapters 3 and 5, were implemented for the sample collection and shipping operations. Although in some cases the judgment of the EPA chemist performing final data review did override the formal quality control procedures, generally data that failed to meet the established quality control limits were not used in the analysis of Survey results. Exhibit E-3 in Appendix E presents the numbers of analyses deleted due to failure to meet quality control guidelines.

4.6 Precision and Accuracy

To determine the precision and accuracy of chemical analyses, field samples were fortified with the method analytes at the primary laboratories (spiked samples). Approximately 40 field samples were fortified at each of three concentrations: two, five, and ten times the MQL for methods 1-7, and two times the MQL, five and ten mg/L as nitrogen for method 9. The precision and accuracy determined from the analyses of field samples fortified at the ten times MQL, methods 1-7, and 10 mg/L, method 9, concentrations indicate that excellent precision and accuracy were obtained over the course of the Survey. Exhibit E-4 in Appendix E presents these results for each analysis method and analyte.

Comparisons of the results of the analyses conducted at the primary laboratories of both fortified field samples and laboratory control standards were used to indicate the effect of the sample matrix (i.e., the well water samples) on the analytical precision and accuracy. These data indicate that there was virtually no impact on analytical precision and accuracy due to the sample matrix.

The results of analyses of laboratory control standards, fortified at ten times the MQL, conducted at both the primary and referee laboratories were used to assess the relative precision and accuracy obtained at each laboratory. These results are presented in Exhibit E-5 in Appendix E for each analysis method and analyte for both primary and referee laboratories. These data indicate that similar precision and accuracy were obtained at b[illegible] primary and referee laboratories.

4.7 Ana[illegible] Stability Studies

A limited study was conducted during methods development and the pilot study to evaluate the stability of the analytes in water samples over time. The purpose of the study was to ensure that the analytes would be stable for the maximum time anticipated between collection and analysis. During methods development, samples of central Ohio ground water were acquired for these experiments. First, this water was analyzed using each of the six newly developed methods to determine if any of the analytes of interest or analyte interferences were observed. Replicate samples were fortified with method analytes and then analyzed after 0, 14, and 28 days storage at 4°C. The extracts obtained during the analyses of the day 0 samples were also analyzed after 14, and 28 days storage. Serious analyte degradation upon storage was observed for 24 of the potential analytes studied, including 22 potential Method #1 analytes, and two potential Method #2 analytes. Eighteen of the potential Method #1 analytes, and two of the potential Method #2 analytes that degraded during storage were deleted from the scope of these two methods. The remaining four potential Method #1 analytes (Disulfoton sulfoxide, Prometon, Pronamide, and Terbufos) were of specific interest to the Agency and were kept within the method scope, pending further studies.

Additional analyte stability studies ("time storage" studies) were conducted throughout the full Survey. The data obtained during the full Survey confirmed those previously obtained, with the exception that no instability problems were encountered for Prometon.

4.8 False Positives and False Negatives

Due to the use of method blanks, appropriate MQLs, and extensive confirmation of all positive results, the risk of any possible false positive was negligible.

Duplicate samples were collected at 5-10 percent of the field sites for analysis at the referee laboratories. Exhibit E-6 in Appendix E presents the results of the comparison of the referee laboratory analyses of each analyte in samples in which this analyte was not observed by the corresponding primary laboratory. Taking differences in MQL into account (referee laboratory MQLs were different from primary laboratory MQLs for many analytes), an analyte detected in the referee laboratory analysis was not observed at the primary laboratory in only two cases out of 200 samples. The largest false negative rate of these two cases -- atrazine -- was only 0.98 percent. Thus, there was a maximum possible false negative rate of approximately 1 percent or less for each analyte.

Chapter Five: Quality Assurance/Quality Control

Introduction

EPA designed and carried out an intensive quality assurance program for the NPS. The key elements of that program – expert review, pilot studies, training, specific standard operating procedures, detailed quality assurance plans, and frequent audits – are recognized as a model for other EPA studies. This chapter discusses the quality assurance/quality control (QA/QC) program for the Survey. In particular, it describes the objectives, organization, and key components of quality assurance and quality control as they relate to each of the major components of the Survey.

5.1 Overview of the Quality Assurance Program

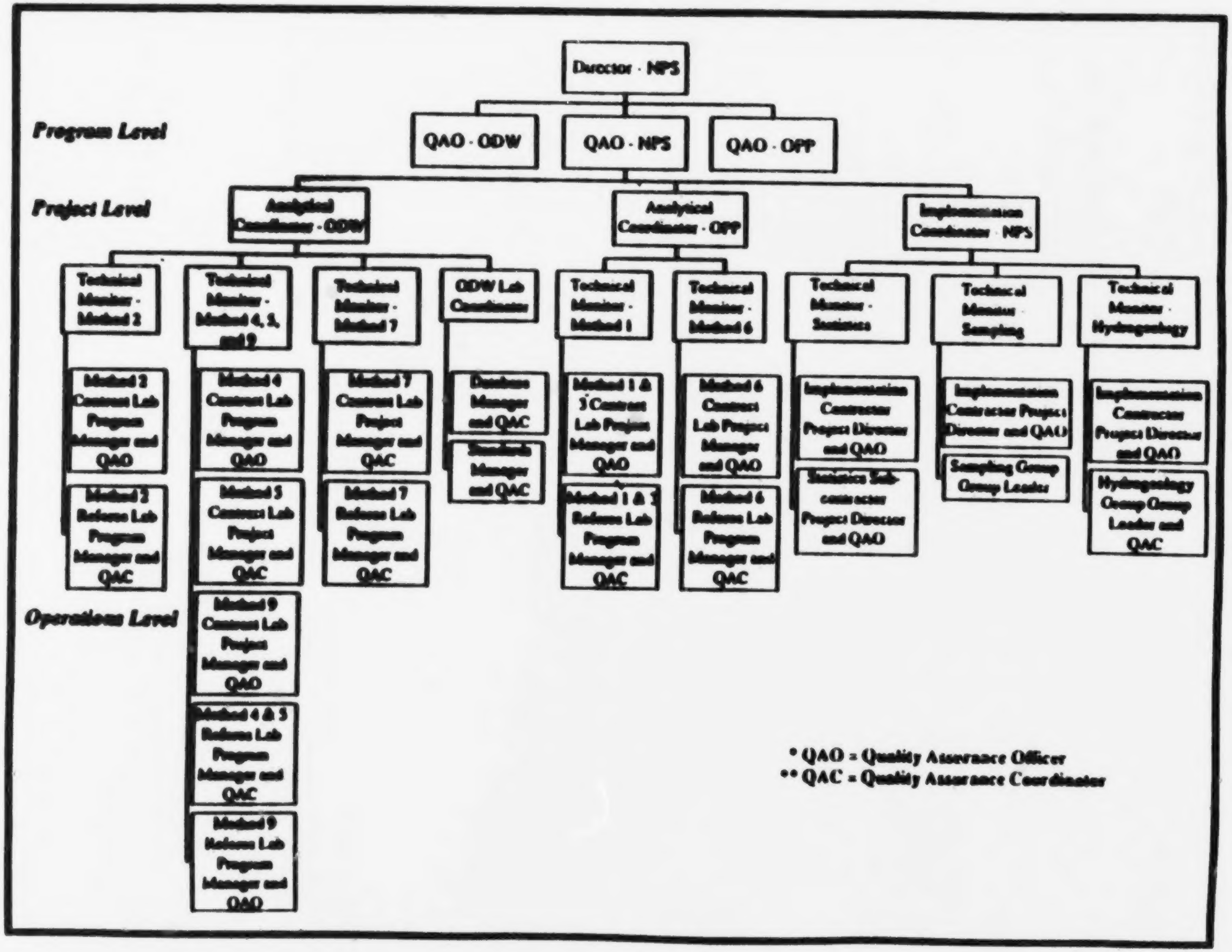
The quality assurance (QA) program for the NPS was designed to encompass all NPS activities to ensure the reliability and validity of data produced by the Survey. This system integrated the quality planning, quality assessment, and quality improvement efforts of various groups in the organization to enable data generators to meet data user requirements. The QA program addressed the activities of ten major organizations across the country responsible for managing the various activities associated with the Survey, including eight laboratories (five contract and three EPA) using eight analytical methods, and one prime contractor and one subcontractor responsible for all non-analytical support activities such as mapping, site selection, training, sampling, questionnaire administration, communications, and database management.

The overall objective of the quality assurance/quality control program was to provide program staff in the Office of Pesticide Programs and the Office of Drinking Water with data of known and useful quality. Using guidance developed by the Quality Assurance Management Staff for EPA quality assurance programs, the NPS QA program monitored and controlled information-gathering processes so that data met design criteria for accuracy, precision, representativeness, comparability, and completeness.

5.1.1 Organization

Responsibility for implementing the quality assurance program rested with a designated Survey Quality Assurance Officer (QAO), a contract QA specialist who reported directly to the Director of the Survey. The Quality Assurance Officers for the Office of Pesticide Programs and the Office of Drinking Water provided independent oversight and guidance to contractors. The Quality Assurance Officer called upon technical staff from organizational units within the Office of Pesticide Programs and the Office of Drinking Water as necessary, for quality assurance support. Typically, the QA support staff had NPS line management responsibilities. For example, the technical monitors who were responsible for overseeing each of the analytical methods often were asked to assist with QA functions. Exhibit 5-1 displays the overall quality assurance organization, including the oversight that was provided by individuals within each organization. As Exhibit 5-1 indicates, overall responsibility for quality assurance rested with the NPS Quality Assurance Officer, who reported to the NPS Director and was provided support by the ODW and OPP Quality Assurance Officers and staff. Analytical coordinators from ODW and OPP assisted the NPS QAO, and supervised EPA technical monitors, who were responsible for ensuring that particular analytic methods were carried out properly by the contract and EPA laboratories performing these methods. An NPS implementation coordinator was responsible for ensuring the reliability and validity of statistical, sampling, and hydrogeological activities, acting with the assistance of EPA technical monitors for each of these activities. Each laboratory and implementation contractor also carried out internal QA/QC functions.

Exhibit 5-1
NPS Quality Assurance Organization


Program Level
Project Level
Operations Level
Director - NPS
QAO - ODW
QAO - NPS
QAO - OPP
Analytical Coordinator - ODW
Analytical Coordinator - OPP
Implementation Coordinator - NPS
Technical Monitor - Method 2
Technical Monitor - Method 4, 5, and 9
Technical Monitor - Method 7
ODW Lab Coordinator
Technical Monitor - Method 1
Technical Monitor - Method 6
Technical Monitor - Statistics
Technical Monitor - Sampling
Technical Monitor - Hydrogeology
Method 2 Contract Lab Program Manager and QAO
Method 2 Referee Lab Program Manager and QAC
Method 4 Contract Lab Program Manager and QAO
Method 5 Contract Lab Project Manager and QAC
Method 9 Contract Lab Project Manager and QAO
Method 4 & 5 Referee Lab Program Manager and QAC
Method 9 Referee Lab Program Manager and QAO
Method 7 Contract Lab Project Manager and QAC
Method 7 Referee Lab Program Manager and QAC
Database Manager and QAC
Standards Manager and QAC
Method 1 & 3 Contract Lab Project Manager and QAO
Method 1 & 3 Referee Lab Program Manager and QAC
Method 6 Contract Lab Project Manager and QAO
Method 6 Referee Lab Program Manager and QAC
Implementation Contractor Project Director and QAO
Statistics Sub-contractor Project Director and QAO
Implementation Contractor Project Director and QAO
Sampling Group Group Leader
Implementation Contractor Project Director and QAO
Hydrogeology Group Group Leader and QAC
* QAO = Quality Assurance Officer
** QAC = Quality Assurance Coordinator

5.1.2 Key Components

The key components of the QA program were planning, program oversight, project oversight, and oversight at the operations level by organizations conducting NPS activities. Each of these components is described in the following sections.

Planning. In order to design the NPS so that the end product would be acceptable to all concerned parties, policy-makers and scientists agreed upon quantitative levels of precision required of the national estimates for pesticide frequency and occurrence that also could be achieved within budgetary and technical constraints. In October 1984, EPA established formal procedures, known as the Data Quality Objective (DQO) process, for reaching consensus on acceptable levels of data quality. NPS planning followed the EPA DQO process, and a DQO document was written in 1987 (see Exhibit 3-2).

Once objectives were clearly stated in the DQO document and the research design was agreed upon, the NPS pilot study was conducted to test the analytical and implementation procedures that were planned for the full Survey. From a quality assurance perspective, the pilot study was extremely useful. Problems with logistics were identified and resolved, and an approach to analytical quality control was selected based on direct comparison of different quality control criteria. The quality assurance program also was refined for the full NPS and the roles of Quality Assurance Officers and the number and types of necessary audits were clarified.

Program Oversight. Program oversight was necessary for coordinating the activities of all participating organizations, for ensuring accuracy and compatibility of data, and for monitoring compliance. Three tools were used to accomplish these goals. The first was the development of a quality assurance program plan, which described NPS policies and procedures for achieving quality. The second was auditing, which was used to communicate Survey expectations with respect to quality to participating organizations and their personnel, to identify potential problems, and to assist in improving the implementation process to ensure high quality data. The third was frequent reporting to Survey management on the status of quality assurance efforts.

Project Oversight. Project oversight was necessary to ensure that technically correct procedures were being employed to generate Survey data. This goal was accomplished by requiring that each discrete Survey activity be described in a quality assurance project plan, in which an operations level internal quality assurance program had to be described, that included all relevant standard operating procedures (SOPs) for that activity. Project plans were approved by the Survey Director and the Quality Assurance Officers for the Office of Drinking Water and the Office of Pesticide Programs. Audits then were conducted using the plans as evaluation criteria to verify that data collection and QA/QC efforts were implemented as described. The technical monitors were primarily responsible for providing oversight at the project level.

Operations Oversight. Each of the organizations, including both EPA and contractors, that participated in the planning and implementation of the Survey carried out internal oversight of their own activities. The personnel who performed this internal oversight function were required to be independent of the data generation processes, yet familiar with the technical aspects of efforts within their organizations in order to perform audits. Each organization's management was then accountable for responding to recommendations made by their own quality assurance staff to ensure that Survey products were delivered at the agreed-upon levels of quality.

Specific information on the QA/QC requirements for each of the analytical and implementation activities can be found in individual quality assurance project plans, available from the National Technical Information Service (NTIS) in Springfield, Virginia. Exhibit 5-2 lists the titles of all NPS quality assurance documents.

Exhibit 5-2
National Pesticide Survey Quality Assurance Plans

OVERALL QUALITY ASSURANCE PROGRAM PLAN (QAPP)

1. Quality Assurance Program Plan for the National Pesticide Survey of Drinking Water Wells, 1988, ICF Incorporated.

ANALYTICAL QUALITY ASSURANCE PROJECT PLANS (QAPjPs)

2. Quality Assurance Project Plan for the National Pesticide Survey of Drinking Water Wells: Analytical Method 1 – Phosphorus Pesticides and Analytical Method 3 - Chlorinated Acid Herbicides, Montgomery Laboratories, September 1990.

3. Quality Assurance Project Plan for the National Pesticide Survey of Drinking Water Wells: Analytical Method 2 – Organochlorine Pesticides, Clean Harbors Incorporated, November 1989.

4. Quality Assurance Project Plan for the National Pesticide Survey of Drinking Water Wells: Analytical Method 4 – Carbamates, Radian Corporation (no date).

5. Quality Assurance Project Plan for the National Pesticide Survey of Drinking Water Wells: Analytical Method 5 – Methylcarbamates, ES&E, July 1990.

6. Quality Assurance Project Plan for the National Pesticide Survey of Drinking Water Wells: Analytical Method 6 – ETU, Battelle - Columbus, April 1990.

7. Quality Assurance Project Plan for the National Pesticide Survey of Drinking Water Wells: Analytical Method 7 – Fumigants, ES&E, July 1990.

8. Quality Assurance Project Plan for the National Pesticide Survey of Drinking Water Wells: Analytical Method 9 – Nitrate/Nitrite, Montgomery Laboratories, May 1990.

9. Quality Assurance Project Plan for the National Pesticide Survey of Drinking Water Wells: Referee Analyses for Analytical Method 1 – Phosphorus Pesticides, Environmental Chemistry Laboratory of the Office of Pesticide Programs - USEPA, December 1988.

10. Quality Assurance Project Plan for the National Pesticide Survey of Drinking Water Wells: Referee Analyses for Analytical Method 3 – Chlorinated Acid Herbicides, Environmental Chemistry Section of the Office of Pesticide Programs - USEPA, December 1988.

11. Quality Assurance Project Plan for the National Pesticide Survey of Drinking Water Wells: Referee Analyses for Analytical Method 6 – ETU, Environmental Chemistry Section of the Office of Pesticide Programs - USEPA, December 1989.

12. Quality Assurance Project Plan for the National Pesticide Survey of Drinking Water Wells: Referee Analyses for Method 2 – Organochlorine Pesticides, Method 4 – Carbamates, Method 5 – Methylcarbamates, Method 7 – Fumigants, and Method 9 – Nitrate/Nitrite, Technical Support Division, Office of Drinking Water and Risk Reduction Engineering Lab, Office of Research and Development, USEPA.

Exhibit 5-2 (continued)
National Pesticide Survey Quality Assurance Plans

IMPLEMENTATION QUALITY ASSURANCE PROJECT PLANS

13. Quality Assurance Project Plan for the National Pesticide Survey of Drinking Water Wells: Hydrogeologic Characterization and Second-Stage Stratification Activities, 1988, rev. 1990, ICF Incorporated.

14. Quality Assurance Project Plan for the National Pesticide Survey of Drinking Water Wells: Well Sampling, Data Collection, and Processing, 1988, rev. 1990, ICF Incorporated.

15. Quality Assurance Project Plan for the National Pesticide Survey of Drinking Water Wells: Survey Statistics, Data Collection and Processing, 1990, ICF Incorporated and Westat Incorporated.

5.2 Quality Control

EPA defines quality control (QC) as the overall system of activities whose purpose is to control the quality of a product so that it meets the needs of its users. Quality assurance is distinguished from QC in that QA is an oversight function and therefore examines and monitors the implementation and effectiveness of quality control. For the NPS, information was generated through physical or chemical measurements, collection of opinions/facts through the use of questionnaires, and from the manipulation of electronically stored data. Quality control activities were used in the NPS to set up, monitor, and adjust information-generating processes to maintain or improve their quality. Quality control took place while the activities were occurring and was performed by those individuals who ran the processes. Both analytical and implementation activities were subject to stringent quality control procedures.

5.2.1 Analytical QC

Depending on the method, each laboratory had to meet specific quality control criteria with respect to initial demonstration of capabilities, method blanks, calibrations, surrogate recoveries, internal standard responses, instrument control standards, lab control standards, control charts, and lab spike samples. They also were required to obtain standard materials from NPS, report in a standardized format on magnetic media, and pass an audit for compliance with required QC criteria for all data sets.

5.2.2 Implementation QC

For the purposes of QC, implementation activities were placed into three categories: well sampling, second stage stratification, and statistics, including questionnaires and data processing. A number of quality control tools were applied to all three categories, including training, development of consistent procedures, expert evaluation of intermediate Survey products (questionnaires, maps, telephone screeners), and monitoring of the progress of the activities to identify and resolve any quality-related problems.

5.3 Audits

The NPS quality assurance program relied very heavily on auditing during implementation. When audits identified deficiencies, corrective action was either taken immediately or coordinated with the technical monitors, depending on the nature of the problem. Implementation of corrective action was monitored and then verified at the next audit. Five types of audits were conducted: Technical System Audits (TSAs), Audits of Data Quality (ADQs), Performance Evaluation (PE) Studies, Close-out Audits, and Internal Audits. Each type of audit is described in this section.

Technical System Audits (TSAs). TSAs were conducted for field, laboratory, and office activities, using the quality assurance project plan for that activity or process as the standard against which the activities were audited. The auditors reviewed each organization's internally-managed quality assurance efforts in addition to their facilities and management systems for the project, data, and documentation. The laboratories also were evaluated against generally accepted good laboratory practices. A team of auditors was used whenever possible. Typically the audit team was composed of QAO(s) and technical monitors. Following each audit, a draft report was written, reviewed by audit participants (including a representative of the audited organization), revised according to review comments, and then forwarded to the Survey Director. Technical system audits were scheduled every six months, or more frequently, if necessary.

Audits of Data Quality (ADQs). ADQs were conducted primarily on laboratory data. The procedure involved tracking a water sample from the time it was received by the laboratory, through analysis, and finally to the reporting of the analytical result to the Survey database manager. All QC criteria were checked and calculations were verified. These audits were performed at the same time as the technical system audits (i.e., every six months).

Performance Evaluation (PE) Studies. Both the contract analytical laboratories and the EPA laboratories participated in performance evaluation studies. Standards, consisting of a mixture of analytes or of single analytes, depending on the method, were prepared in an appropriate solvent, verified, and shipped to the laboratories in sealed glass ampules with directions for preparation as an aqueous sample. Laboratories then were checked for correct identification and quantification of the compounds in the standard. Performance evaluation studies were conducted on a quarterly basis and were carried out for all analytical methods.

Close-out Audits. Close-out audits were required of every organization that participated in NPS as a check that all work had been completed and all technical supporting materials had been organized and filed in a manner consistent with the Survey policy on archival records (i.e., materials must be managed so that they are readily accessible for reference purposes). Close-out audits were performed following the cessation of NPS-sponsored activities.

Internal Audits. Internal audits were audits of operations conducted by QA staff employed by the organizations actually performing the work. The auditors therefore were more familiar with procedures, policies and problems inherent to organizations than could be the team of auditors led by the NPS QAO. Major responsibility for quality assurance was thus delegated to the lowest organizational level possible. The frequency with which these audits were held was identified in each of the quality assurance project plans and varied among organizations according to the extent of their role in NPS and available resources. Results of the audits were summarized in monthly progress reports and discussed during NPS systems audits.

5.4 Corrective Action Summary

Audits typically identified discrepancies that required corrective actions, such as a process improvement, rather than a need to stop work due to an out-of-control situation. On several occasions, problems were identified that required Survey management to intervene to correct deficiencies. Ultimately, corrective action was not used to assign blame but rather was viewed as an effort to improve quality. The balance of this section describes the types of discrepancies and corrective actions identified in the audits. The types of discrepancies identified in Technical System Audits ranged in seriousness from those that had already compromised data quality to those that were simply questionable procedures. The number of problems in the first category were very few and consisted of issues such as exceeded sample holding times, improper sample storage, and incorrect interpretation of questionnaire terms. Much more numerous were those problems that had the potential to result in the loss of data, such as computer files that had not been archived, a calibration standard that was no longer accurate, and a vendor supply problem with teflon-lined caps for sample bottles. These situations were identified as potential problems and corrected before they could result in data loss.

Data audits, because they were an intensive review of the result generation process, were very productive for verifying that procedures were followed exactly as the procedures were described in the quality assurance project plan or were specified during the Technical Systems Audit. Typically, the laboratories were found to be following their procedures as described, and the problems that were identified were very specific, such as incorrect interpretation of the time storage analysis scheme or the lack of analysis of a required quality control sample.

PE studies were useful for demonstrating laboratory capabilities with respect to identifying and quantifying NPS analytes and proved to be an excellent tool for identifying problems that had previously gone undetected. Over the course of six PE studies, the laboratories successfully identified more than 98 percent of the analytes, as shown in Exhibit 5-3. Also shown in Exhibit 5-3 are the number of PE observations that met study criteria for quantification. Overall, 93 percent of the laboratory results met study criteria, a slightly lower percentage than for correct identification.

An example of a problem that was detected through the performance evaluation studies was a misidentification of the elution order for two compounds on the Method 2 confirmatory column. On another occasion, a problem existed with consistently quantifying a Method 3 analyte accurately, even though all the quality control indicators for the method met the criteria. The primary laboratories worked cooperatively with the technical monitors and EPA laboratories to resolve these problems.

Close-out audits were a powerful tool for enforcing requirements for long-term management of Survey data. Unlike all previous audits, which were conducted with an end goal of process improvement, the close-out audits were a mechanism to ensure that organizations pulled together all materials they had generated for NPS, filed them in an organized fashion, and maintained their safety and security.

Many of the deficiencies discovered by the auditors during the close-out audits were corrected at that time. Any remaining issues were corrected later and verification of the correction was made by the on-site QA personnel. A typical example of a deficiency that was identified on these audits was the absence of a complete record. Corrective action, therefore, entailed locating the files and physically placing them with all other NPS materials. An index to the records was required, and often this was not generated until the auditor made the request in person. Given the follow-up that typically occurred subsequent to the close-out audits, these audits were extremely successful for achieving the desired end result, i.e., that a complete record be maintained in an organized fashion for several years under safe and secure conditions.

Exhibit 5-3
Summary of Performance Evaluation Results

	Performance Evaluation Study					
	1988	1989				1990
Number of Analytes*	18	26	28	27	20	22
Number of Observations**	36	52	51	46	34	38
Number within Criteria for:						
Identification	36	52	48	45	34	38
Quantification	34	51	48	38	34	35

Overall percentage correctly identified: 98 percent
Overall percentage correctly quantified: 93 percent

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* PE studies cover all analytic methods.
** Number of observations includes results from analyses performed at both the contract and EPA referee labs.

Chapter Six: Findings and Results

Introduction

This chapter presents Survey findings and results based upon the data obtained from the analysis of well water samples and the data obtained from Survey questionnaires collected and analyzed by the NPS. These results are stated in terms of the estimated number or proportion of community water system wells and rural domestic wells in the United States with a particular characteristic. These findings have been calculated from the results of the analysis of water samples obtained from 540 CWS wells and 752 rural domestic wells. Because the Survey's national findings depend on a multi-stage sampling design, weighted estimates of the number and percent of wells are presented, along with measures of the estimates' accuracy.

Results are presented in the order of EPA's objectives and Survey design specifications. These objectives and specifications are also crucial to interpreting the Survey's key findings correctly. EPA's first objective was to estimate the frequency and concentration of pesticides and nitrate in drinking water wells on a national level. EPA's second objective was to collect sufficient data to examine the relationships between the presence of pesticides and nitrate in drinking water wells and patterns of pesticide use and ground-water vulnerability. EPA established precision criteria for national level estimates for rural domestic wells and community water system wells to meet the first objective. The 127 NPS analytes were selected to provide a national-level assessment of the presence in drinking water wells of those chemicals that had been detected in local monitoring studies, were suspected of leaching to ground water, or had major agricultural use patterns. EPA, however, did not design the Survey to target areas where specific pesticides are used or "hot spots" where specific pesticides had previously been detected in ground water.

National estimates in this chapter are presented in terms of an estimate with upper and lower limits for analytical data; such limits are also presented in Appendix D for questionnaire data. These limits define the "confidence interval" and reflect the relative certainty of population estimates that are based on data from the wells sampled by the Survey. They indicate the upper and lower limits of the range that EPA is reasonably confident contains the actual detection rate for wells nationally. Estimates in this chapter are presented with a 95 percent confidence interval. Confidence intervals for numbers and percents of population estimates are not always symmetrical (i.e., they are not an equal amount above and below the estimate) because of their underlying statistical distribution.

The NPS provides estimates for five important subgroups of U.S. wells, in addition to estimating the rates of detection of pesticides in U.S. wells nationwide. EPA defined these subgroups of wells (domains of interest) in areas of high pesticide use, vulnerable ground water, and intensive agricultural activity. The Survey design also provided that if specific analytes occurred frequently, estimates of the occurrence and concentration of these individual chemicals could be provided for the nation. EPA did not design the Survey, however, to estimate the [illegible] and concentration of individual analytes.

In [illegible] the NPS, other surveys have been designed to produce estimates of the presence of one or more specific pesticides in particular regions of the country. For example, Monsanto and the Research Triangle Institute, with the active participation of EPA, designed the National Alachlor Well Water Survey (NAWWS) to estimate the proportion of private, rural domestic wells with detectable concentrations of the herbicide alachlor. The NAWWS was designed to estimate contamination in counties where alachlor was used rather than in the nation as a whole. The Iowa State-Wide Rural Well-Water Survey was designed to provide statistically valid estimates, both State-wide and within regions of the State, of the quality of water supplies.

This chapter is divided into six sections. Section 6.1 presents estimates of the number of CWS wells and the number of rural domestic wells in the United States containing nitrate or at least one pesticide. Well population estimates and proportions of wells are based upon detections of any pesticide and nitrate in the community water system wells and rural domestic wells included in the Survey.

Section 6.2 presents national estimates for specific NPS analytes. Section 6.2.1 presents estimates for the three chemicals detected most frequently in the Survey -- nitrate, the pesticide degradate DCPA acid metabolites, and the pesticide atrazine. Section 6.2.2 presents national estimates for ten additional pesticides that were detected in the Survey above Survey Minimum Reporting Limits (MRLs), but which were detected less frequently than nitrate, DCPA acid metabolites, and atrazine. Finally, Section 6.2.3 presents national estimates for the presence in drinking water wells of analytes that were not detected in the Survey. Wells nationwide may contain other NPS analytes not detected during the Survey for several reasons. The Survey used a stringent series of minimum reporting limits and laboratory confirmation requirements to ensure a high degree of certainty about the detections that were reported. Additional NPS analytes may have been present in the wells sampled at levels too low to be reported as detections by the Survey. In addition, the Survey sampled a limited number of wells in randomly selected geographic areas of the country. Public and private wells in local areas with high levels of NPS analytes may not be included in the Survey due to random selection. EPA will conduct extensive analysis of the Survey results to understand if these factors affected Survey findings. Research plans for these additional analyses are discussed in Section 6.6.

Section 6.3 presents data on the concentrations of chemicals detected most frequently in water samples, and compares those concentrations when possible to regulatory and health standards established by EPA to protect human health. Two such standards, Maximum Contaminant Levels (MCLs) and Lifetime Health Advisory Levels (HALs), are discussed. Although MCLs apply by law only to community water systems, they also are used in this chapter as a standard of quality for source drinking water for rural domestic wells. It also is important to note that while these standards pertain to water after treatment, the water samples collected and analyzed in the Survey were obtained from CWS wells and rural domestic wells before water from these wells had undergone any treatment. NPS field teams purged wells from 10 to 30 minutes before taking samples, to ensure that samples were not stagnant water from the piping system or treated water that had back-siphoned into the well. EPA also conducted intensive monitoring of Survey field teams and sampling records to ensure that samples were collected prior to water treatment. Sample results indicating any violations of sampling procedures were deleted from the final data base used to prepare the estimates presented in Chapter 6. Although nitrate, DCPA acid metabolites, and atrazine were all detected with sufficient frequency to enable statistically valid analysis of concentration levels to be completed for them, only nitrate was detected with sufficient frequency to provide enough cases for comparing its measured concentration with regulatory and health standards. Section 6.3.1 presents concentration data for nitrate, and compares nitrate concentration to EPA health standards. Section 6.3.2 presents concentration data for DCPA acid metabolites and atrazine. Section 6.3.2 also presents a consolidated national estimate for the presence of Survey analytes in drinking water wells above the health-based limits. Comparisons of these chemicals with EPA health-based standards are based on the upper bound of a 95% confidence interval.

Section 6.4 presents a summary of survey-derived information about the construction and condition of CWS wells and rural domestic wells, and about pesticide use, farming activities, and other characteristics of the areas surrounding the wells. This information was obtained from the Survey questionnaires administered to well owners or operators and local area experts and is presented on a national basis.

Section 6.5 describes Survey results for certain subgroups of the population (domains of interest) of drinking water wells that were identified as being of special interest to the Survey. Five subgroups are described: community water system wells in counties with high ground-water vulnerability, rural domestic wells in counties with high ground-water vulnerability, rural domestic wells in counties with high pesticide use, rural domestic wells in counties with high pesticide use and high ground-water vulnerability, and rural domestic wells in "cropped and vulnerable" portions of counties. Section 6.5 presents data on these subgroups of wells that are derived both from the analysis of well water samples and from questionnaires.

Section 6.6 describes the analyses that EPA is planning to conduct in Phase II of the Survey of the relationships between data on pesticide and nitrate detections and various categories of information about wells gathered during the Survey, such as pesticide use, well depth, and geologic characteristics.

6.1 National Estimates

One of the two major objectives of the National Pesticide Survey was to estimate the number of drinking water wells in the nation that contain at least one pesticide or pesticide degradate. The Survey tested approximately 1300 wells across the country for the presence of 101 pesticides, 25 pesticide degradates, and nitrate[1] (127 analytes). The Survey was designed to provide statistical estimates, using the results obtained from those sampled wells, of the approximate number of wells in the United States containing at least one pesticide or nitrate. This section presents national estimates of the frequency with which drinking water wells contain any pesticide or nitrate. It also summarizes the information obtained by the Survey about the occurrence of specific pesticides and pesticide degradates.

Section 6.1.1 provides summary national estimates of the number of drinking water wells nationwide, in order to establish the baseline for the other estimates presented in this chapter. Section 6.1.2 presents estimates for the number and proportion of community water system wells and rural domestic wells that contain at least one Survey analyte. These estimates are based on survey data for the 112 quantifiable NPS analytes. (The remaining 15 analytes could not be reliably measured and therefore are described as qualitative analytes.)

The analytical results presented in this report reflect the detection limits of the contract laboratories that conducted the analytical determinations for the Survey. In all, 17 analytes were detected. Thirteen were detected at levels above the NPS MRLs used by the contract laboratories that performed the initial analysis of samples; three were detected by EPA laboratories at concentrations lower than the respective contract laboratory MRLs. Because EPA laboratories analyzed only about 10% of all sampled wells, such detections are not included for statistical analysis in this report, but will be discussed further in the NPS Phase II Report. In several cases pesticide detections were used from the EPA laboratories to replace the contract laboratory results. In these cases, the EPA laboratory detection limits were slightly higher than the contract laboratory limits. One detected chemical could not be measured, and that detection also is not included for statistical analysis. In the balance of this chapter, the term "detection" is used to mean a detection at concentrations at or above the contract laboratory MRL. The MRL is defined as one-half of the Minimum Quantification Limit (MQL) (see Section 4.3).

6.1.1 National Estimates of Wells

At the commencement of the design of the Survey, EPA estimated that in the United States there were approximately 51,000 community water systems using ground water and, based on the 1980 census, estimated that there were approximately 13 million rural domestic wells. Based on the Survey results, EPA now estimates that there are approximately 38,300[2] community water systems with ground-water wells in the United States, which together operate 94,600 wells (Exhibit 6-1). The number of CWS wells nationally could be as high as [illegible] or as low as 90,900, as indicated by the associated 95 percent confidence interval. The number of rural domestic wells nationally is now estimated to be 10.5 million from data obtained from the 1987 American Housing Survey (AHS) conducted by the U.S. Bureau of the Census. Given the change in rural populations since 1980, the 1987 AHS estimates provide a more accurate basis for estimating NPS results

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[1] Samples were analyzed for the combined presence of nitrate and nitrite, and reported as a single concentration in milligrams per liter (mg/L) as nitrogen.

[2] Estimates over 1,000 are rounded to three significant digits; estimates under 1,000 are rounded to two significant digits. Percents are rounded to one decimal place.

Exhibit 6-1
Estimated Number of Drinking Water Wells in the United States

Domain Description	Estimated Number	95% Confidence Interval (lower - upper)
Community water system wells	94,600	(90,900 - 98,300)
Rural domestic wells	10,500,000	

than 1980 Census estimates. The AHS estimate is treated as a constant for the NPS, and therefore does not have an associated error bound (95% confidence interval) to measure its precision. A detailed explanation of these adjustments to the Survey's initial population estimates is presented in Appendix B.

6.1.2 National Estimates for Pesticides and Nitrate

The NPS obtained water samples from 566 CWS wells and 783 rural domestic wells. After technical review of individual well plumbing systems and sample collection procedures, however, not all water samples met NPS quality control standards. Therefore, this chapter presents summary results based on samples from the 540 CWS wells and 752 rural domestic wells whose samples met the Survey's quality assurance/quality control criteria.

The national estimates in this chapter of the number and proportion of all CWS wells and rural domestic wells that contain Survey analytes are derived from the Survey data using appropriate weights. That is, the Survey was designed so that the number of detections of analytes in the 540 CWS wells and 752 rural domestic wells are used as the basis of a calculation that weights them according to precise factors that account for the multi-stage Survey design and provides estimates representative of the 94,600 CWS wells and 10.5 million rural domestic wells in the United States.[3]

A graphic summary of the weighted estimates of the percent of CWS wells and rural domestic wells with nitrate and pesticides above Survey minimum reporting limits is presented in Exhibit 6-2. This exhibit shows the estimated percent of wells nationally that contain detections (above the MRLs) of pesticides only, nitrate only, and nitrate plus pesticides. The percent indicating wells with nitrate and pesticides represents the national estimate of wells containing both pesticides and nitrate.

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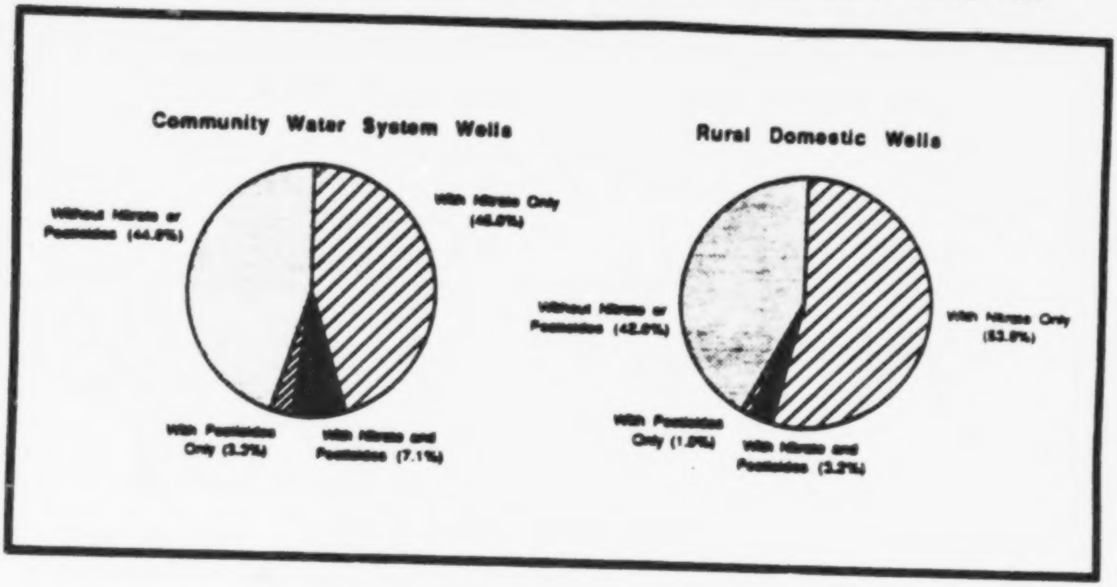
[3] The "weight" of a survey well corresponds loosely to the number of wells it represents in the population and is equal to the inverse of its probability of selection for the Survey. A more detailed discussion of the actual calculations is given in Appendix B.

Exhibit 6-2
Estimated Percent of Community Water System Wells and Rural Domestic Wells in the United States with Nitrate and/or Pesticides



National Estimates for Specific Pesticides

This section provides national estimates for the number of wells in the United States that contain pesticides, based on the pesticide detections in the Survey. In order to provide national estimates for the presence of pesticides in drinking water wells nationwide that are both statistically valid and developed on a standard basis, only those pesticide detections measured by the five contract laboratories are included in the calculation of national estimates. Survey results shown in Exhibit 6-3 indicate that:

- About 9,850 (10.4%) of the CWS wells in the United States are estimated to contain concentrations above the MRL for at least one pesticide. Considering the related confidence interval,[4] this estimate could be as low as 6,330 or as high as 13,400; and
- About 446,000 (4.2%) of the rural domestic wells in the United States are estimated to contain concentrations above the MRL for at least one pesticide; this estimate could be as low as 246,000 or as high as 647,000.

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[4] For most of the estimates presented in this chapter, the underlying statistical distribution is binomial (e.g., a well water sample either does or does not test positive for analyte detection). When the sample size is large enough and the estimated percent is not near zero or 100, confidence intervals are based on the normal distribution approximation to the binomial distribution. When the sample size is not large enough to justify the normal approximation, however, confidence intervals for the analytical results are based on the binomial distribution instead of the normal approximation. Confidence intervals based on the binomial distribution generally are not symmetric. A more detailed discussion of the actual calculations is given in Appendix B.

Exhibit 6-3
Estimated Number and Percent of Drinking Water Wells in the United States Containing at Least One Pesticide

Domain Description	Estimated Number	95% Confidence Interval (lower - upper)	Estimated Percent	95% Confidence Interval (lower - upper)
Community water system wells	9,850	(6,330 - 13,400)	10.4	(6.8 - 14.1)
Rural domestic wells	446,000	(246,000 - 647,000)	4.2	(2.3 - 6.2)

National Estimate for Nitrate

Nitrate is the analyte most frequently detected in both CWS wells and rural domestic wells, and was detected at a much higher frequency than specific pesticides and pesticide degradates. Survey results indicate that over half of the CWS wells and rural domestic wells in the United States contain levels of nitrate at or above the survey's MRL of 0.15 mg/L (Exhibit 6-4).

Exhibit 6-4
Estimated Number and Percent of Wells in the United States Containing Nitrate

Domain Description	Estimated Number	95% Confidence Interval (lower - upper)	Estimated Percent	95% Confidence Interval (lower - upper)
Community water system wells	49,300	(45,300 - 53,300)	52.1	(48.0 - 56.3)
Rural domestic wells	5,990,000	(5,280,000 - 6,700,000)	57.0	(50.3 - 63.8)

National estimates for nitrate are presented separately because of the differences between nitrate and the other analytes. Nitrate (NO_3^-) is not regulated under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Nitrate can occur naturally or as a result of human activity. It is found in some fertilizers or as a result of nitrification of ammonium fertilizers. Nitrate is produced in soil through nitrification and mineralization. Nitrogen is present in discharges from septic systems, animal feed lots, industrial wastewaters, and sanitary landfills. Nitrite (NO_2^-) is an intermediate product of the conversion of ammonium (NH_4^+) to nitrate or as the intermediate product of the conversion of nitrate to ammonium. Nitrate and nitrite were not separately distinguished in the Survey laboratory method and testing, and the results presented reflect both nitrate and nitrite, measured as nitrogen (N) in mg/L.

Exhibits 6-5 and 6-6 present graphic summaries of the national estimates for drinking water wells containing at least one detected pesticide and for wells containing nitrate.

Exhibit 6-5
Estimated Percent of Community Water System Wells and Rural Domestic Wells in the United States Containing at Least One Pesticide

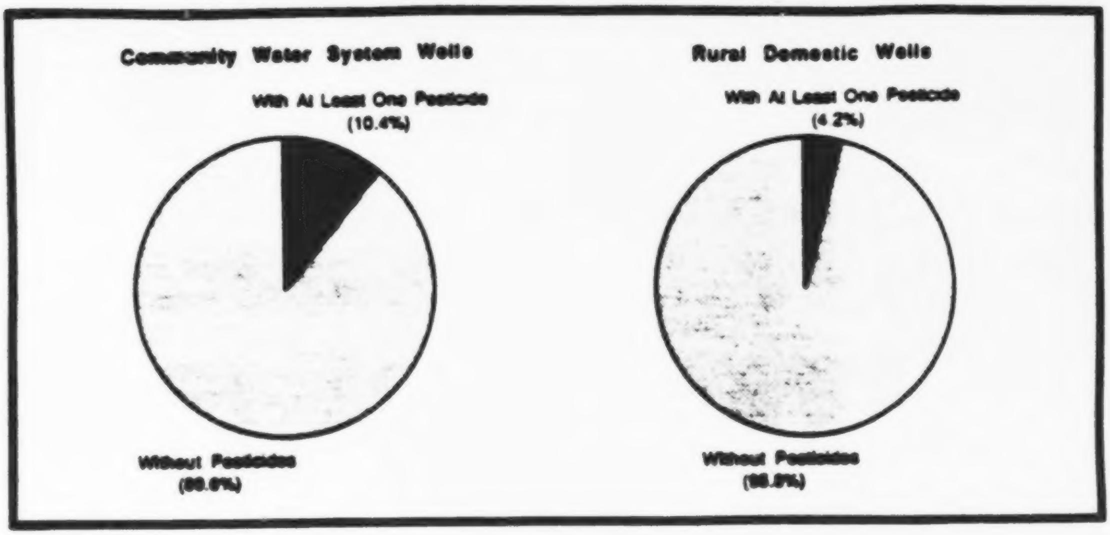
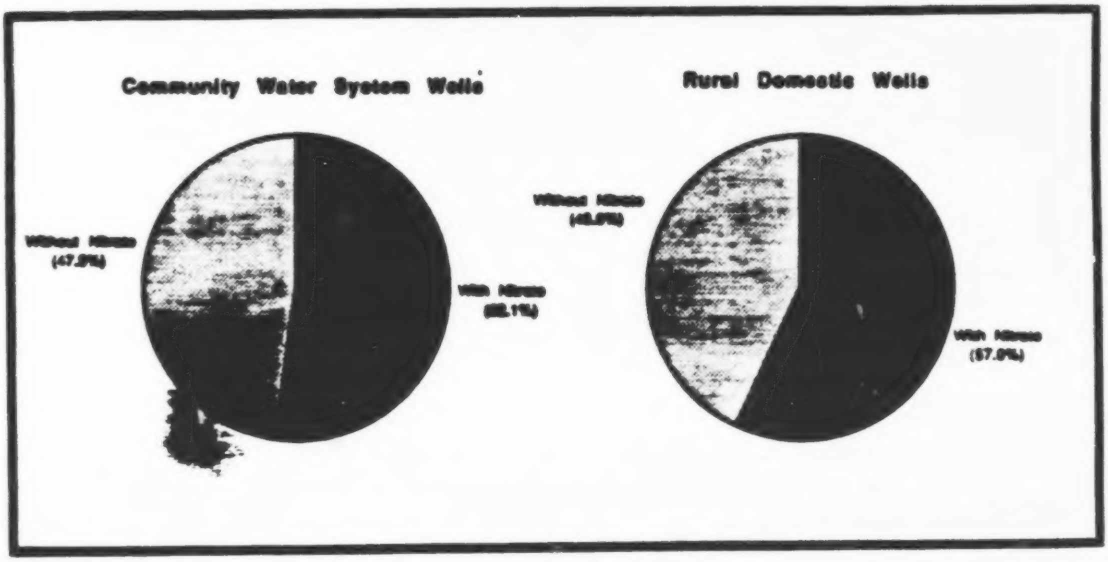


Exhibit 6-6
Estimated Percent of Community Water System Wells and Rural Domestic Wells in the United States Containing Nitrate[a]



[a] The minimum reporting limit for nitrate is 0.15 mg/L.

6.2 National Estimates for Pesticides

This section presents national estimates of the frequency of occurrence in drinking water wells in the United States of the pesticides and pesticide degradates detected in the Survey and for all other pesticide analytes. Section 6.2.1 provides estimates for the two most frequently detected pesticides, DCPA acid metabolites and atrazine. Section 6.2.2 provides estimates for 10 other pesticides or pesticide degradates detected at concentrations above their respective MRLs. Finally, Section 6.2.3 presents national estimates (using the upper bound of a 95% confidence interval) for those pesticide analytes that were not detected.

6.2.1 National Estimates for Two Most Frequently Detected Pesticides: DCPA Acid Metabolites and Atrazine

Two analytes -- DCPA acid metabolites (degradates of DCPA) and the pesticide atrazine -- were the most frequently detected pesticide analytes. This section presents estimates of the national frequency of occurrence of these two analytes in drinking water wells.

As Exhibit 6-7 indicates, approximately 6,010 CWS wells and 264,000 rural domestic wells are estimated to contain DCPA acid metabolites. These numbers could be as high as 8,840 and 477,000 or as low as 3,170 and 129,000. Approximately 1,570 CWS wells and 70,800 rural domestic wells are estimated to contain atrazine. These numbers could be as high as 2,710 and 214,000 or as low as 420 and 13,300 for CWS and rural domestic wells.

Exhibit 6-7
Estimated Number and Percent of Wells in the United States Containing DCPA Acid Metabolites or Atrazine[a]

Domain Description	Estimated Number	95% Confidence Interval (lower - upper)	Estimated Percent	95% Confidence Interval (lower - upper)
Community water system wells:				
DCPA acid metabolites	6,010	(3,170 - 8,840)	6.4	(3.4 - 9.3)
Atrazine	1,570	(420 - 2,710)	1.7	(0.5 - 2.9)
Rural domestic wells:				
DCPA acid metabolites	264,000	(129,000 - 477,000)	2.5	(1.2 - 4.5)
Atrazine	70,800	(13,300 - 214,000)	0.7	(0.1 - 2.0)

[a] The minimum reporting limit for DCPA acid metabolites is 0.10 $\mu g/L$ and the minimum reporting limit for atrazine is 0.12 $\mu g/L$.

Dimethyl tetrachloroterephthalate (DCPA), a selective herbicide registered in 1958, is the parent compound of DCPA acid metabolites. DCPA, which was not detected in the Survey, is sold under the trade name Dacthal W-75 and has been sold under the discontinued trade names of DAC-893 and Fatal. The primary use of DCPA, more than 80%, is on turf such as golf courses and home lawns. It is used to combat smooth and hairy crabgrass, witchgrass, green and yellow foxtails, fall panicum, and other annual grasses. It is also used against certain broadleaf weeds such as carpet weed, dodder, purslane, and common chickweed, and is tolerated by many crop plants. It is presently approved for use on turf, ornamentals, strawberries, collards, cucumbers, eggplant, garlic, horseradish, kale, mustard greens, onions, peppers, potatoes, radish, seeded melons, squash, sweet potatoes, tomatoes, turnips, and soybeans. DCPA acid metabolites have a high potential to migrate through soil due to their high water solubility.

Atrazine is the common name of an herbicide which is a member of the chemical family of triazines. Atrazine was registered in the late 1950's. It has been sold under the trade names of Atrazine, AAtrex, Atrasol, Ge[illegible] and Zeaphos. Atrazine is a component of other herbicides such as Bicep, Bullet, Extrazine, D[illegible], Prozine, and Sutazine. Atrazine is used to control many annual broadleaf weeds and certain g[illegible] corn, sorghum, sugarcane, macadamias, and subtropical tree fruits such as guavas and pineapples. [illegible] used for general weed control on non-cropped industrial land, selective weed control in conifer restoration and Christmas tree plantations, and non-selective control of vegetation on fallow land. Atrazine has a high potential to migrate through soil due to its water solubility and relatively long half-life. Exhibits 6-8 and 6-9 present graphic representations of the proportion of CWS wells and rural domestic wells nationally containing DCPA acid metabolites, and the proportion of drinking water wells containing atrazine.

6.2.2 National Estimates for All Analytes Detected

In addition to DCPA acid metabolites and atrazine, 10 other pesticides or pesticide degradates were detected above NPS minimum reporting limits. With some exceptions, these analytes were detected at both CWS wells and rural domestic wells. The following lists identify all analytes detected above minimum reporting limits and whether they were detected at a CWS well or rural domestic well:

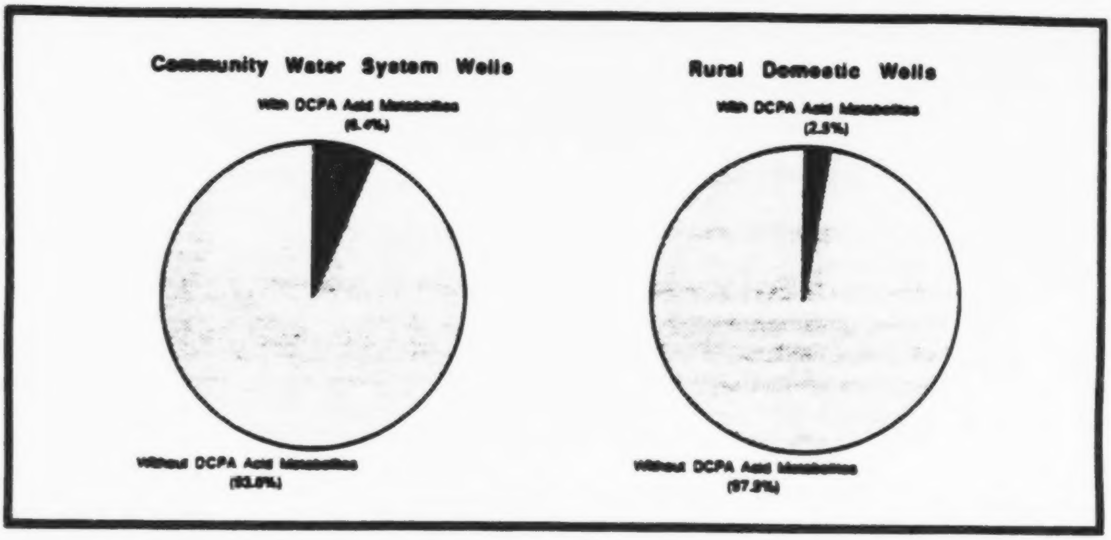
- **CWS wells:** atrazine, DCPA acid metabolites, dibromochloropropane, dinoseb, hexachlorobenzene, nitrate, prometon, and simazine; and
- **Rural domestic wells:** alachlor, atrazine, bentazon, DCPA acid metabolites, dibromochloropropane, ethylene dibromide, ethylene thiourea, gamma-HCH, nitrate, prometon, and simazine.

The following exhibits (Exhibits 6-10 and 6-11) provide national estimates of the number and proportion of the 94,600 community water system wells and 10.5 million rural domestic wells containing these pesticides (national estimates for nitrate, DCPA acid metabolites, and atrazine also are included for ease of comparison).

In addition to the pesticides discussed in this section, for which estimates are shown in Exhibits 6-10 and 6-11, three analytes (alpha-chlordane, gamma-chlordane, and beta-HCH) were detected by the EPA laboratories at concentrations much lower than the respective MRLs used by the contract laboratories. The EPA laboratories had the task of verifying the results of the contract laboratories, and in many cases were able to detect analytes at concentrations lower than the MRLs established for the Survey. National estimates cannot be produced for these analytes because the EPA laboratories did not analyze water samples from every well. In addition, one analyte, 4-nitrophenol, was detected, but national estimates could not be produced due to limitations of the laboratory analytic method for this chemical.

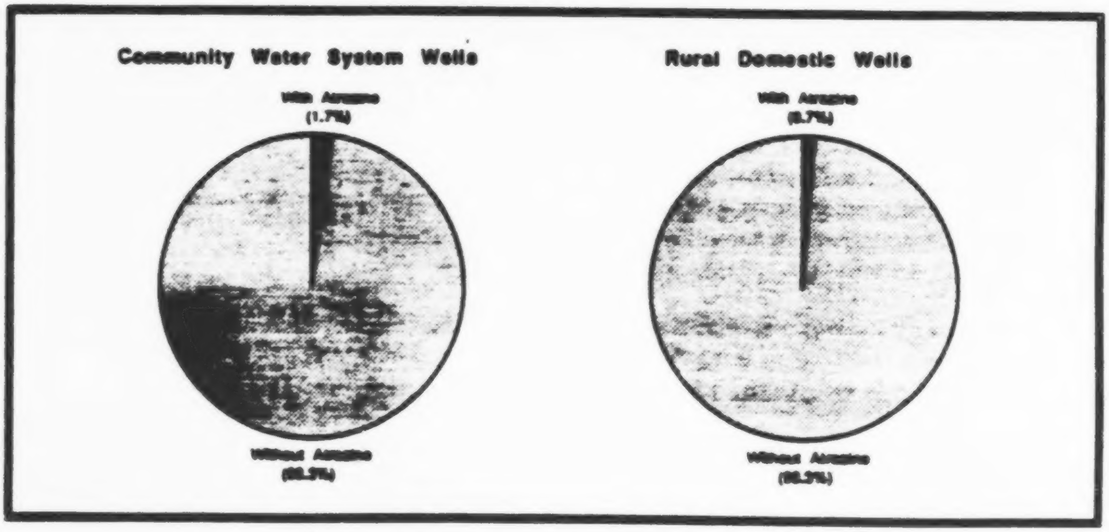
E[illegible] information regarding the predominate uses of the pesticides and pesticide degrad[illegible] Survey and their behavior in the environment. Seven of the 14 analytes have a high potent[illegible] Of these 14 pesticides, 9 have an MCL and 8 have a Lifetime HAL.

Exhibit 6-8
Estimated Percent of Community Water System Wells and Rural Domestic Wells Containing DCPA Acid Metabolites[a]



[a] Minimum reporting limit = 0.10 μg/L.

Exhibit 6-9
Estimated Percent of Community Water System Wells and Rural Domestic Wells Containing Atrazine[a]



[a] Minimum reporting limit = 0.12 μg/L.

Exhibit 6-10
Estimated Number and Percent of Community Water System Wells Containing NPS Analytes

Analyte	Estimated Number	95% Confidence Interval (lower - upper)	Estimated Percent[b]	95% Confidence Interval (lower - upper)
Nitrate	49,300	(46,300 - 53,300)	52.1	(50.0 - 56.3)
DCPA acid metabolites	6,010	(3,170 - 8,840)	6.4	(3.4 - 9.3)
Atrazine	1,570	(420 - 2,710)	1.7	(0.5 - 2.9)
Simazine	1,080	(380 - 2,840)	1.1	(0.4 - 2.7)
Prometon	520	(78 - 1,710)	0.5	(0.1 - 1.8)
Hexachlorobenzene[a]	470	(61 - 1,630)	0.5	(0.1 - 1.7)
Dibromochloropropane (DBCP)[a]	370	(33 - 1,480)	0.4	(<0.1 - 1.6)
Dinoseb[a]	25	(1 - 870)	<0.1	(<0.1 - 0.9)

[a] Registration cancelled by EPA.
[b] Numbers between zero and 0.05 are reported as less than 0.1 (<0.1).

Exhibit 6-11
Estimated Number and Percent of Rural Domestic Wells Containing NPS Analytes

Analyte	Estimated Number	95% Confidence Interval (lower - upper)	Estimated Percent[b]	95% Confidence Interval (lower - upper)
Nitrate	5,990,000	(5,280,000 - 6,700,000)	57.0	(50.3 - 63.8)
DCPA acid metabolites	264,000	(128,000 - 477,000)	2.5	(1.2 - 4.5)
Atrazine	70,800	(13,300 - 214,000)	0.7	(0.1 - 2.0)
Dibromochloropropane (DBCP)[illegible]	38,400	(2,740 - 184,000)	0.4	(<0.1 - 1.6)
Prom[illegible]	25,800	(840 - 142,000)	0.2	(<0.1 - 1.4)
Sima[illegible]	25,100	(880 - 141,000)	0.2	(<0.1 - 1.3)
Ethyl[illegible]	18,200	(160 - 131,000)	0.2	(<0.1 - 1.2)
gamma-HCH (Lindane)	13,100	(14 - 120,000)	0.1	(<0.1 - 1.1)
Ethylene thiourea (ETU)	8,470	(1 - 111,000)	0.1	(<0.1 - 1.1)
Bentazon	7,160	(1 - 109,000)	0.1	(<0.1 - 1.0)
Alachlor	3,140	(1 - 101,000)	<0.1	(<0.1 - 1.0)

[a] Registration cancelled by EPA.
[b] Numbers between zero and 0.05 are reported as less than 0.1 (<0.1).

Exhibit 6-12
Key Characteristics and Uses of Detected Pesticides

Analyte	Type	Potential to Migrate in Soil[a]	Key Use
Alachlor	Herbicide	Medium	Controls annual grasses and weeds in corn, soybeans, and peanuts
Atrazine	Herbicide	High	Controls certain weeds in corn, sorghum, sugarcane, pineapple, and citrus fruits
Bentazon	Herbicide	High	Controls broadleaf weeds in soybeans, rice, corn, peanuts, beans, peas, and mint
Chlordane	Insecticide	Low	Controls termites in homes and other insects such as fire ants around underground cables
DCPA acid metabolites	Herbicide (degradate)	High	Controls annual grasses in turf ornamentals, fruits, and vegetables
Dibromochloropropane (DBCP)[b]	Herbicide	High	Controls nematodes on berries, citrus, melons, and nuts (cancelled)
Dinoseb[c]	Herbicide	Medium	Controls potato vines and desiccating seed crops (cancelled)
Ethylene Dibromide (EDB)[d]	Insecticide	High	Controls insects in soil (cancelled) and is an additive in leaded gasolines
Ethylene thiourea (ETU)[e]	Fungicide (degradate)	Medium	Breakdown product of EBDC fungicides (cancelled)
Hexachlorobenzene[b,f]	Fungicide	Medium	Controls fungus on wheat (cancelled)
Gamma-HCH (Lindane)	Insecticide	Medium	Controls leafhoppers in lowland rice and wood inhabiting beetles
4-Nitrophenol	Insecticide (degradate)	High	Degradate of parathion pesticides which control a variety of insects such as aphids and mosquitoes on pears and apples
Prometon	Herbicide	High	Controls perennials, broadleaf weeds, and grasses in non-crop areas
Simazine	Herbicide	Medium	Controls annual grasses and weeds in crops especially corn and fruit such as citrus, asparagus, and nuts

[a] Migration potential based on an assessment of available data on physical and chemical properties, including water solubility, soil adsorption coefficients, and half-life data.

[b] Cancelled.

[c] Commercial use suspended in 1986.

[d] Cancelled in 1984.

[e] EPA proposed the cancellation of many of the uses of the parent compounds in 1989.

[f] Also a contaminant of several chlorinated pesticides.

6.2.3 National Estimates for Analytes Not Detected

Many of the 127 Survey analytes were not detected in water samples collected in the Survey. These analytes, however, may or may not be present in drinking water wells in the United States. In the NPS, because only a relatively small group of wells in the population were sampled, wells containing specific pesticides might not have been selected for participation in the Survey. Estimates for these analytes were developed based on the upper bound of a 95% confidence interval. If EPA had sampled every well in the population (i.e., conducted a census), the presence of some pesticides or nitrate above an MRL would probably have been detected.

Exhibit 6-13 presents estimates for the maximum numbers and percents of CWS wells and rural domestic wells potentially containing at least one pesticide that was not detected in the Survey. The estimates in this exhibit suggest, for example, that no more than 750 (0.8%) CWS wells in the United States contain pesticides not detected in the Survey. The estimate of 0.8% is a 95% upper confidence bound for the proportion of wells containing at least one pesticide that was not detected in the Survey.[5]

Exhibit 6-13
Estimates of the Maximum Number of Drinking Water Wells Containing Pesticides Not Found in the Survey

Domain Description	Estimated Number	Estimated Percent
Community water system wells	750	0.8
Rural domestic wells	83,100	0.8

6.3 Estimated Concentrations of Frequently Detected Analytes and Comparison to Regulatory and Health Limits

This section presents concentration levels of those analytes that were detected in sampled well water with sufficient frequency so that the statistical measures for the concentrations can be provided. It presents four measures of concentration: the minimum concentration, which corresponds to the minimum reporting limit for the analyte; the maximum concentration detected; the median concentration, above and below which there are an equal number of observations; and the weighted geometric mean and its confidence interval. The geometric mean is an appropriate statistic for data where the observations tend to cluster at the lower values (i.e., are positively skewed).

Section 6.3.1 presents concentration estimates for nitrate, the most frequently detected analyte. DCPA acid metabolites and atrazine were detected with sufficient frequency in the Survey so that statistically reliable analyses of concentration levels of these chemicals in drinking water wells in the United States could be completed. Section 6.3.2 presents estimated concentration levels for the two analytes.

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[5] For additional details on the calculation, see Section B6.4 of Appendix B.

This section also presents estimates of the number of wells in the United States containing nitrate at concentration levels that exceed certain regulatory or health-based levels for nitrate. Nitrate was the only analyte that was detected often enough to produce an estimate of the relationship of detected concentrations to regulatory and health levels for that analyte. DCPA acid metabolites were not detected at concentrations above the HAL of 4,000 μg/L (ppb) and atrazine was not detected often enough at concentrations above its MCL and HAL of 3 μg/L to provide reliable estimates. Estimates of the numbers of wells in the United States with at least one pesticide above health-based standards also are presented. This topic will be investigated in the Phase II Report.

6.3.1 Estimated Nitrate Concentrations

As Exhibit 6-14 shows, the median concentration for nitrate in the wells in which it was detected is 1.6 mg/L for both CWS wells and rural domestic wells. The geometric means for nitrate concentrations in CWS and rural domestic wells also were estimated for the United States. The geometric mean concentration of nitrate in CWS wells and rural domestic wells is 1.3 and 1.4 mg/L, respectively. The 95% confidence interval for these estimates indicates that the geometric means could be at any point between 1.1 to 1.5 mg/L and 1.1 to 1.8 mg/L, respectively. As Exhibit 6-14 shows, both the geometric mean and the median are below the health-based standard of 10 mg/L for nitrate. The geometric mean and confidence intervals are not based on the normal distribution (see Appendix B for additional discussion).

Exhibit 6-14
Concentrations of Nitrate Detected in Wells Sampled by NPS

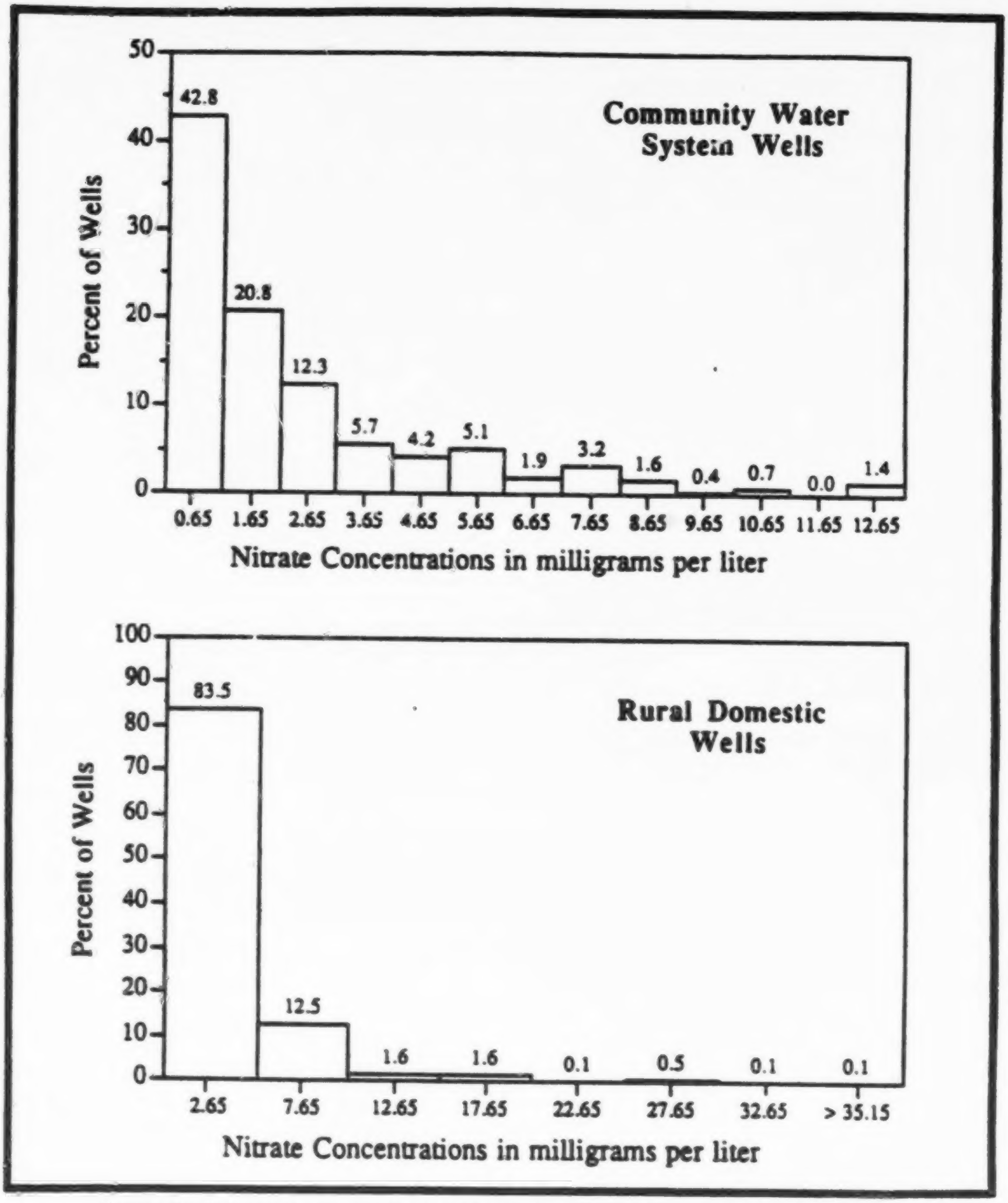
Domain Description	Concentration (mg/L)[a]				
	Minimum Reporting Limit	Geometric Mean	95% Confidence Interval	Median	Maximum
Community water system wells	0.15	1.3	(1.1 - 1.5)	1.6	13
Rural domestic wells	0.15	1.4	(1.1 - 1.8)	1.6	120

[a] The geometric mean estimate is based on weighted national data, and the median and maximum are based on sample data only.

It is important to note, with respect to the concentrations reported in Exhibit 6-14, that although detections were not publicly reported with a measured concentration between the MRL and the MQL of an analyte, these concentrations were used in the calculation of the values presented in Exhibit 6-14. The median and maximum are based on sample data only. In contrast, the geometric mean estimate is based on weighted national data. Details of calculations of the geometric means and confidence intervals are provided in Appendix B.

Exhibit 6-15 presents the estimated frequency distributions for nitrate concentrations for CWS wells and rural domestic wells in the United States. The frequencies, which are based on weighted survey results, are national estimates for each concentration interval or group presented. For instance, EPA estimates that for CWS wells nationally that contain nitrate above the Survey detection level of 0.15 mg/L, 42.8% contain nitrate at concentrations between 0.15 and 1.15 mg/L (centered at 0.65 mg/L) and for rural domestic wells nationally that contain nitrate above the Survey detection level, 83.5% contain nitrate at concentrations between 0.15 and 5.15 mg/L (centered at 2.65 mg/L). For both CWS wells and rural domestic wells nationally, most observations are at concentrations below the MCL/HAL for nitrate of 10 mg/L.

Exhibit 6-15
Estimated Frequency Distribution of Nitrate Concentrations of Community Water System Wells and Rural Domestic Wells Sampled by NPS[a]



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[a] Percent of wells based on water samples containing nitrate levels greater than or equal to the minimum reporting limit of 0.15 mg/L. Numbers presented for nitrate concentrations are mid-points of the frequency intervals. For example, concentrations between 0.15 and 1.15 mg/L are centered at 0.65 mg/L.

Nitrate in ground water can originate from sources such as rain (as well as acid rain) and normal biological activities. The major source of nitrate in cultivated soils is from inorganic fertilizers containing nitrogen. Nitrogen fertilizers are applied to soils to enhance plant growth and nitrogen is necessary in the synthesis of plant proteins. Other sources of nitrate in soil and water include septic systems, animal wastes, plant residues, and fixation from the atmosphere. Exhibit 6-16 compares nitrate concentration to the regulatory standard established under the Safe Drinking Water Act (SDWA) for nitrate. The standard used as the basis of comparison is the Maximum Contaminant Limit (MCL) of 10 mg/L, which in the case of nitrate equals the Health Advisory Level (HAL).[6] The MCL is a regulatory standard, legally applicable under the SDWA only to public water systems. It represents the maximum level of a contaminant that may be contained in water delivered by a piped system of supply serving 15 or more connections or a population of at least 25 persons. MCLs apply to water at the tap, following treatment, and are not applicable to surface or ground-water sources of drinking water. Although the MCL is not legally applicable to rural domestic wells, it was used for this analysis as a standard of quality for source drinking water. HALs represent the maximum concentration of a contaminant in water that may be consumed safely over an average human lifetime. EPA calculated national estimates of the number of wells containing concentrations of nitrate based on the sample data and national estimates of nitrate detections at levels above the health-based standard of 10 mg/L. The health effects caused by these chemicals are described in Health Advisory Summaries prepared by EPA.

Exhibit 6-16
Estimated Number and Percent of Wells with Nitrate Contamination in the United States Above the Health-Based Standard

	Nitrate Estimate Above MCL/HAL[a]			
Domain Description	Estimated Number	95% Confidence Interval (lower - upper)	Estimated Percent	95% Confidence Interval (lower - upper)
Community water system wells	1,130	(370 - 2,600)	1.2	(0.4 - 2.7)
Rural domestic wells	254,000	(128,000 - 464,000)	2.4	(1.2 - 4.4)

[a] The MCL and HAL for nitrate are both 10 mg/L.

Survey results include several important findings concerning the frequency with which the concentrations of nitrate in drinking water wells may exceed health-based standards. EPA estimates that:

- More than half of the CWS wells in the United States (about 52.1% or 49,300 wells) contain detectable levels of nitrate. About 1.2% of all CWS wells (approximately 1,130 wells) contain nitrate concentrations that exceed the MCL/HAL of 10 mg/L; and

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[6] The Health Advisory Level (HAL) is defined as the level of exposure to contaminants at which adverse health effects would not be expected to occur in most members of the population. Unlike MCLs, which are enforceable standards, HALs are non-enforceable health-based guidelines. HALs are calculated for various periods of exposure, including one day, 10 days, and longer term (e.g., few months to lifetime); lifetime HALs are used in this report. HALs are developed using data related to non-carcinogenic toxic effects. Some analytes have Risk Specific Doses (RSDs) instead of or in addition to HALs. The RSD represents the concentration of a chemical in drinking water that, if consumed for a lifetime, would result in an excess lifetime cancer risk of one in one million.

- About 57.0% of rural domestic wells in the United States (approximately 5,990,000 wells) contain detectable levels of nitrate; about 2.4% of all rural domestic wells (about 254,000 wells) contain nitrate levels that exceed the MCL/HAL.

From the measured concentration data, EPA found that:

- The maximum concentration of nitrate detected in CWS wells was approximately 13 mg/L; and
- The maximum concentration of nitrate detected in rural domestic wells was approximately 120 mg/L.

6.3.2 Estimated Pesticide Concentrations

DCPA acid metabolites and atrazine were the only pesticides detected with sufficient frequency for reliable concentration estimates to be developed based on their detections. Exhibit 6-17 presents those estimates. Although detections were not publicly reported with a measured concentration between the MRL and the MQL for DCPA acid metabolites and atrazine, these concentrations were used in the calculation of the geometric mean, and the median and the maximum. In contrast to the median and maximum, which are calculated from sample data, the geometric mean is calculated from weighted national data.

As Exhibit 6-17 indicates:

- In sampled CWS wells, maximum concentrations of DCPA acid metabolites and atrazine were approximately 7.2 and 0.92 μg/L, respectively.
- In sampled rural domestic wells, maximum concentrations of DCPA acid metabolites and atrazine were approximately 2.4 and 7.0 μg/L, respectively.

Exhibit 6-17
Concentrations of DCPA Acid Metabolites and Atrazine Detected in Wells Sampled by NPS

Domain Description	Concentration (μg/L)[a]				
	Minimum Reporting Limit	Geometric Mean	95% Confidence Interval	Median	Maximum
Community water system wells:					
DCPA acid metabolites	0.10	0.56	(0.35 - 0.89)	0.34	7.2
Atrazine	0.12	0.40	(0.20 - 0.81)	0.26	0.92
Rural domestic wells:					
DCPA acid metabolites	0.10	0.37	(0.22 - 0.63)	0.38	2.4
Atrazine	0.12	0.44	(0.18 - 1.04)	0.28	7.0

[a] The geometric mean estimate is based on weighted national data, and the medium and maximum are based on sample data only.

As Exhibit 6-17 indicates, the geometric mean concentrations of DCPA acid metabolites in CWS wells and rural domestic wells throughout the United States are 0.56 and 0.37 μg/L, respectively. The geometric mean for CWS wells could be as low as 0.35 μg/L or as high as 0.89 μg/L, as indicated by the 95% confidence interval. Similarly, the geometric mean for rural domestic wells could be as low as 0.22 μg/L or as high as 0.63 μg/L. Fifty percent of DCPA acid metabolite detections in CWS wells and rural domestic wells were less than the median values of 0.34 and 0.38 μg/L, respectively.

The geometric mean concentrations of atrazine detections in CWS wells and rural domestic wells are 0.40 and 0.44 μg/L, respectively. The geometric mean for CWS wells could be as low as 0.20 μg/L or as high as 0.81 μg/L, as indicated by the 95% confidence interval. Similarly, the geometric mean for rural domestic wells could be as low as 0.18 μg/L or as high as 1.04 μg/L. Fifty percent of atrazine detections in CWS wells and rural domestic wells were at concentrations less than the median values of 0.26 and 0.28 μg/L, respectively.

The confidence intervals for the geometric means are calculated for each well population individually; they do not account for the relationship between CWS and rural domestic well detections. Statistical tests to determine the extent of the differences between geometric means for CWS wells and rural domestic wells will be performed in Phase II.

Finally, EPA calculated estimates of the number and percent of community water system wells and rural domestic wells in the United States with at least one pesticide detection above health-based standards. Exhibit 6-18 presents these estimates.[7]

Exhibit 6-18
Estimated Number and Percent of Wells in the United States with at Least One Pesticide Detection Above Health-Based Standard[8]

Domain Description	Estimated Number	95% Confidence Interval (lower - upper)	Estimated Percent	95% Confidence Interval (lower - upper)
CWS wells above MCL/HAL	0	(0 - 750)	0.0	(0.0 - 0.8)
Rural domestic wells above MCL/HAL	60,900	(9,430 - 199,000)	0.6	(0.1 - 1.9)

[a] MCLs are not legally applicable to rural domestic wells.

As Exhibit 6-18 illustrates:

- At most 0.8% (750 wells) of CWS wells in the United States contain at least one pesticide above health based standards; and
- Of rural domestic wells in the United States, approximately 0.6% (60,900) have concentrations above their respective MCLs[8] and HALs. This percent could be as low as 0.1% or as high as 1.9%, as indicated by the associated 95% confidence interval.

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[7] These calculations assume that the probability of detection follows a binomial distribution, and takes into account the complex sample design by using appropriate weights. A more detailed discussion of the actual calculations is given in Appendix B.

[8] This estimate is based on those pesticides that have an associated MCL or HAL (see Appendix E, Exhibit E-1).

6.4 Characteristics of CWS Wells and Rural Domestic Wells

The second major purpose of the NPS is to investigate the relationship between the presence of pesticides and nitrate in drinking water wells and a number of factors potentially affecting that presence, such as pesticide use, ground-water vulnerability, well construction and maintenance, and farming activities conducted in the vicinity of wells. In order to gather data on these factors, several detailed questionnaires were administered to the owners or operators of wells, householders using rural domestic wells, farmers, and local area experts such as county agricultural extension agents. This section presents national estimates of the characteristics of CWS wells and rural domestic wells, based on the data compiled from the field questionnaires. Copies of these questionnaires are provided in Appendix D. In addition, detailed compilations of the results for key questionnaire items are provided in Appendix D, with indications of the particular questionnaires and questions from which the data are compiled.[9] Exhibits in Appendix D also include the 95% confidence intervals for these data.

- Section 6.4.1 discusses characteristics of CWS wells;
- Section 6.4.2 discusses characteristics of rural domestic wells; and
- Section 6.4.3 contrasts CWS well and rural domestic well characteristics.

These characteristics are described to help interpret the analytical results of the Survey. Phase II of the NPS will investigate further the association among nitrate detections, pesticide detections, pesticide use, well depth, age of well, and geologic characteristics. The Phase I Report is not intended to determine statistical differences between related items. The confidence intervals presented are for single characteristics only and do not take into account the relationship between variables.

6.4.1 Characteristics of CWS Wells

National estimates for CWS wells based on the responses to key questionnaire items are presented in Appendix D,[10] which presents descriptive statistics in three broad categories: (1) characteristics of the well and surrounding area; (2) farming and land use; and (3) pesticide use. This section presents highlights of the descriptive information collected in that appendix.

Questionnaire responses show that about 15,900 CWS wells, which is equivalent to about 16.8% of CWS wells nationally, belong to systems with one working well (see Item I.1 in Exhibit D-1 in Appendix D).[11] Some additional statistics of interest in Exhibit D-1 include the following:

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[9] The data are compiled from the CWS and Domestic Well Team Leader Introduction (TLI) and Well Observation Record (WOR), The CWS and Domestic Well Main Questionnaires (CWS Main and DWS Main), and the CWS and Domestic Local Area Questionnaires (LAQ).

[10] In Appendix D, for those questions where the possible Survey responses are mutually exclusive and exhaustive, the number and percent estimates sum exactly to the domain population size and one hundred percent, respectively. Rounding errors presented with the questionnaire responses can cause the summations to appear inexact. A few questionnaire items do not contain a mutually exclusive or exhaustive list of possible responses. The sum of estimates for these questionnaire responses should not be expected to correspond to the domain population sizes or one hundred percent. All confidence intervals in Appendix D are based on the normal approximation to the binomial distribution.

[11] Numbers corresponding to responses have been included for reviewing Appendix D for ease of comparison between the domains of interest. These numbers do not, however, correspond to numbering schemes used in any Survey questionnaires. Some questionnaire items contain skip patterns (i.e., instructions to skip particular questions based on previous answers). A questionnaire item is presented as a single item, including sub-items resulting from skip patterns in the questionnaires which are separated with a blank line.

- Almost half (44.5%) of all CWS wells are in systems with only one or two wells (see Item L1);
- About 35.6% of the CWS wells nationally are more than 20 years old (see Item L6);
- For about 72.4% of the wells, the land area within 300 feet of the well is primarily exposed or vegetated soil (e.g., permeable to precipitation) (see Item L4);
- Most of the wells (83.9%) are capped at the ground surface (see Item L10); concrete pads (about 78.0%) and sanitary or grouted seals (about 69.2%) are used alone or in combination for ground surface protection at the majority of the well sites (see Item L5); and most wells (about 99.0%) are cased, about 46.2% of cased wells are cased to their total depth (see Item L9), and about 69.6% of cased wells are grouted (see Item L9);[12]
- Approximately 56.2% of the wells are deeper than 200 feet, whereas about 38.4% of the wells are less than 200 feet deep (see Item L8). For the remaining wells the response to the question was "don't know" (see footnote 12); and
- Approximately 43.5% of the wells tap confined aquifers (see Item L12).

Farming and Land Use Near CWS Wells

Survey questionnaire data indicate that:

- About 7.4% of the properties where CWS wells are located were farmed in the last 5 years (see Item L18);
- About 40.3% of the wells are located within 1/2 mile of land on which crops have been farmed within the last 3 years (see Item L22); approximately 41.0% of the wells are located within 1/2 mile of land used as pasture within the last 3 years (see Item L23);
- About 9.5% of the wells are located within 1/2 mile of a golf course; most (about 83.3%) are located within 1/2 mile of a surface water body (see Items L27 and L28); and
- Approximately 25.0% of the wells are located within 1/2 mile of irrigated land (see Item L29).

Pesticide Use Near CWS Wells

Key questionnaire results on pesticide use include:

- About 7.4% of all CWS wells are located on farm property; pesticides are used at approximately 34.4% of these farm properties (see Item L18);
- About 41.0% of CWS wells are located within ½ mile of pasture lands; pesticides were used within the last 3 years on approximately 57.2% of these pasture lands (see Item L23). This corresponds to about 23.5% CWS wells in the United States (confidence intervals for calculation of national estimates for such "nested" data will be provided in Phase II);

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[12] Many of the questionnaire items listed in the exhibits in Appendix D contain "don't know" as a possible response. Summary results presented in the text treat this response as being exclusive of all other possible responses. For instance, the statement that "approximately 69.6% of cased CWS wells are grouted" does not allow for the approximately 18.9% "don't know" response. The "don't know" responses affect Survey estimates. In this example, since a well is either grouted or not grouted, then considering this form of measurement error only, the percent of cased CWS wells that are grouted could lie between 69.6% and 88.5%. The questionnaire item responses as presented portray measurement error through the "don't know" response and sampling error through the 95% confidence interval.

- Approximately 25.5% of CWS wells nationally are located on properties where non-farm pesticides have been used within the last 3 years; at about 73.5% of these properties, pesticides have been used within 100 feet of the well (see Item I.14). This corresponds to about 18.7% CWS wells in the United States (confidence intervals for calculation of national estimates for such "nested" data will be provided in Phase II); and

- At about 19.8% of the CWS wells, major non-farm pesticides[13] (e.g., spraying for gypsy moth or mosquitoes) were applied within 1/2 mile of the well in the last 3 years (see Item I.24).

6.4.2 Characteristics of Rural Domestic Wells

Statistics for questionnaire variables for rural domestic wells nationally also are presented in Appendix D, Exhibit D-3. Rural domestic well characteristics, farming and land use, and pesticide use are highlighted below:

- For most rural domestic wells nationally (about 91.1%), the land area within 300 feet of the well is primarily exposed or vegetated soil (e.g., permeable to precipitation) (see Item I.3);

- Most (79.8%) rural domestic wells are closed (i.e., capped) at the ground surface (see Item I.9); about 85.8% are cased, and about 47.5% of cased wells are cased to their total depth (see Item I.8);

- Most wells (87.7%) have not been redrilled (see item I.6); and

- Approximately 22.4% of the wells are deeper than 200 feet, whereas about 62.6% of the wells are less than 200 feet deep (see Item I.7). For the remaining wells the response to the question was "don't know" (see footnote 12).

Farming and Land Use Near Rural Domestic Wells

Survey questionnaire data indicate that:

- About 11.7% of rural domestic wells nationally are located on properties that are farmed (see Item I.17);[14]

- Approximately 66.2% of the wells are located within 1/2 mile of land where crops have been farmed within the last 3 years (see Item I.21); about 65.4% of the wells are located within 1/2 mile of land used as pasture within the last 3 years (see Item I.22);

- About 5.0% of rural domestic wells nationally are located within 1/2 mile of a golf course; approximately 93.8% are located within 1/2 mile of a surface water body (see Items I.27 and I.28); and

- About 18.1% of the wells are located within 1/2 mile of irrigated land (see Item I.29).

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[13] The NPS defined farm pesticides as all chemicals used to control insects, plants, fungi, nematodes, and rodents. Farmed property is a place where the sale of crops or animals, exceeds an amount of $1,000 and includes land in a land bank if the farmer could have earned $1,000 or more.

[14] EPA estimated the number of rural domestic wells located on farm property in the United States (1,220,000) from the 1987 American Housing Survey.

Pesticide Use Near Rural Domestic Wells

Key questionnaire results on pesticide use include:

- Farm pesticides have been used in the last five years at about 83.6% of farmed properties that have well sites (see Item L18);
- Pesticides have been applied in the last three years to 41.1% of the pasture land located within ½ mile of wells (see Item L23);
- Non-farm pesticide use on the properties on which rural domestic wells are located includes use inside the home (about 75.7%), use on lawns (about 40.0%), and garden use (about 41.9%) (see Items L12, L13, and L14);
- At about two thirds of the rural domestic well sites (67.7%), non-farm pesticides have been stored on the property for at least one month in the last three years; in 72.0% of these wells they were stored within 100 feet of the well (see Item L15); and
- At about 13.9% of the wells, major non-farm pesticides (e.g., spraying for gypsy moth or mosquitoes) were applied within 1/2 mile of the well in the last 3 years (see Item L24).

6.4.3 Summary of CWS and Rural Domestic Well Characteristics

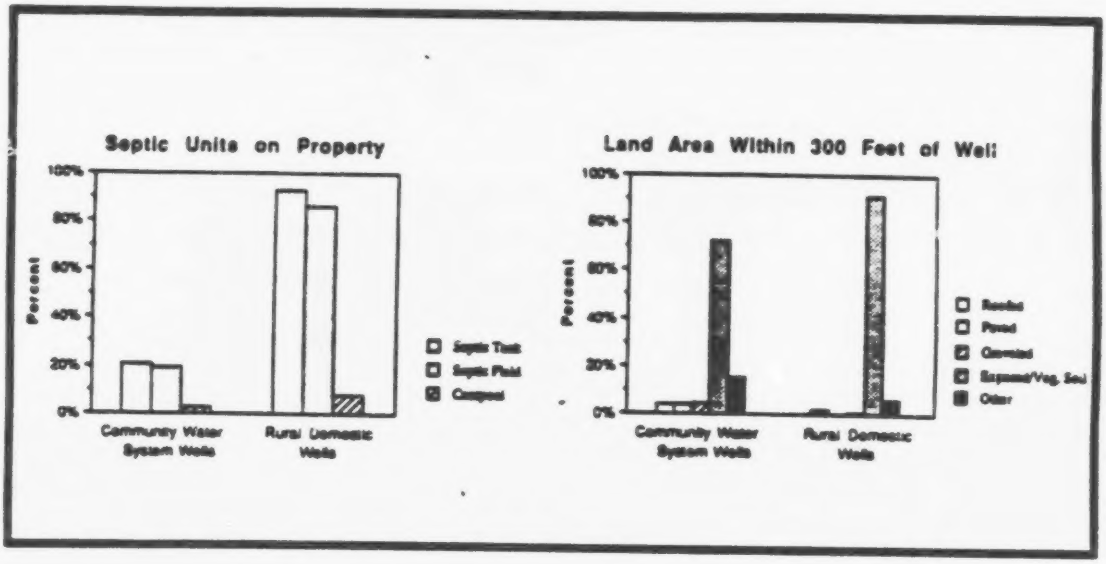
One of the objectives of the Survey is to explore the relationships among variables for CWS wells and rural domestic wells. These two populations of drinking water wells have certain common characteristics; a number of differences between them, however, were captured by some of the questionnaire data that were collected about both CWS wells and rural domestic wells. The following exhibits organize data in three categories -- well setting, well construction and condition, and land and pesticide use near wells. Exhibits 6-19, 6-20, and 6-21 provide graphic comparisons showing estimated percents of specific questionnaire responses on a national basis for these three categories. The confidence intervals presented in Appendix D for CWS wells and rural domestic wells are calculated for each well characteristic individually; they do not account for the relationship among variables. Caution should be exercised in drawing comparisons between related items until appropriate statistical tests are performed during Phase II. Responses to questionnaire items frequently included "don't knows." "Don't know" responses are not included in population estimates reporting a given characteristic. Consequently, these comparisons should be reviewed with caution.

Key results illustrated by these exhibits include the following:

Well Setting

- Rural domestic wells are approximately four times as likely as community water systems to have septic units on the property where the well is located (Exhibit 6-19); and
- Land area within three hundred feet of both CWS wells and rural domestic wells is predominantly exposed or vegetated soil (Exhibit 6-19).

Exhibit 6-19
Comparison of Well Setting

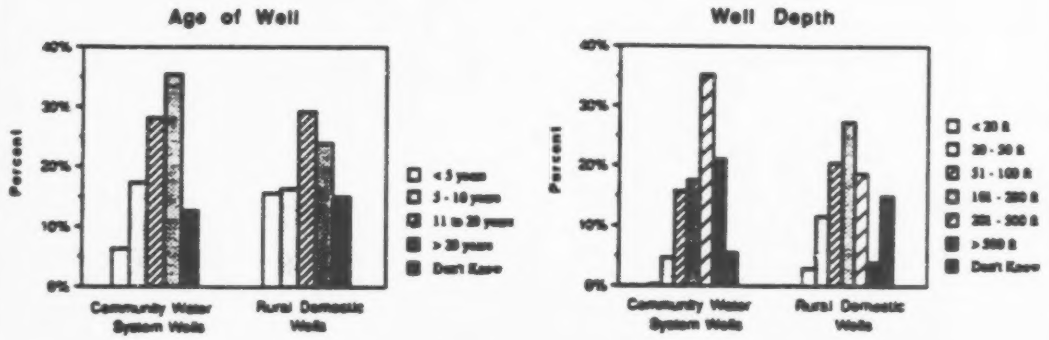


Well Construction and Condition

- Community Water System wells tend to be older than rural domestic wells; approximately 35.6% of CWS wells are more than 20 years old, while about 24.0% of rural domestic wells are more than 20 years old (Exhibit 6-20); and

- CWS wells tend to be deeper than rural domestic wells; about 22.4% of rural domestic wells are deeper than 200 feet whereas about 56.2% of CWS wells are deeper than 200 feet (Exhibit 6-20).

Exhibit 6-20
Comparison of Well Construction and Condition



Land and Pesticide Use

- Approximately 7.4% of CWS properties were used for farming in the last 5 years, compared to about 11.7% for rural domestic well properties (Exhibit 6-21);

- Pesticides were used more frequently on farmed properties where rural domestic wells are located during the past 5 years than on farmed properties where CWS wells are located (Exhibit 6-21);

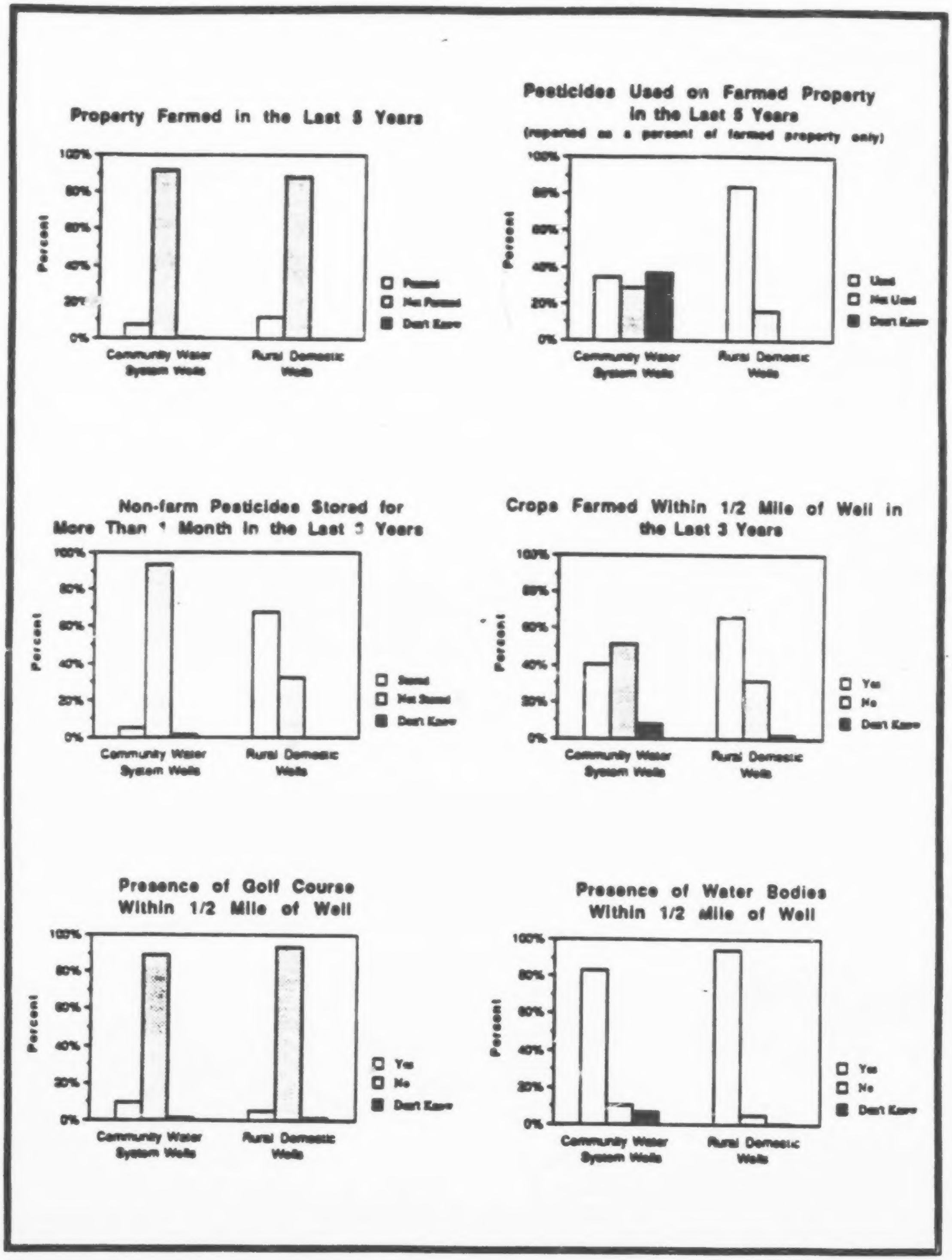
- Non-farm pesticides are stored on CWS properties much less frequently than on rural domestic well properties (Exhibit 6-21);

- Farming within 1/2 mile occurs much more frequently near rural domestic wells than CWS wells (Exhibit 6-21);

- Approximately 9.5% of CWS wells and 5.0% of rural domestic wells are located within 1/2 mile of a golf course (Exhibit 6-21); and

- Approximately 83.3% of CWS wells and 93.8% of rural domestic wells are located within 1/2 mile of a body of water (river, canal, bay, pond) (Exhibit 6-21).

Exhibit 6-21
Comparison of Land and Pesticide Use



6.5 Populations of Domains of Special Interest

The Survey findings and results presented in this chapter to this point have been for all CWS and rural domestic wells in the United States. In addition to national estimates for all wells, however, EPA also designed the NPS to provide summary statistics for five domains (subgroups) of the entire population of drinking water wells that are of special interest to EPA. These domains were selected to provide data to better understand how the presence of pesticides or nitrate in drinking water wells is associated with patterns of pesticide use and ground-water vulnerability. The five domains are:

- CWS wells in counties with high ground-water vulnerability as measured by DRASTIC (first stage strata 1, 4, 7, and 10, see Chapter 2);
- Rural domestic wells in counties with high ground-water vulnerability as measured by DRASTIC (first stage strata 1, 4, 7, and 10, see Chapter 2);
- Rural domestic wells in counties with high pesticide use (first stage strata 1, 2, and 3);
- Rural domestic wells in counties with high pesticide use and high ground-water vulnerability as measured by DRASTIC (first stage strata 1); and
- Rural domestic wells in "cropped and vulnerable" portions of counties (second stage stratification).

The categories of results reported in this section parallel the categories used to report national estimates. First, Section 6.5.1 provides estimates for the numbers of wells nationwide, that belong to each of the five domains. Section 6.5.2 provides estimates for the number of wells in the United States in each domain containing at least one detected analyte. Finally, Section 6.5.3 provides information on well characteristics.

6.5.1 Well Populations of Domains of Interest

EPA prepared estimates of the five domains of interest (subgroups) of CWS wells and rural domestic wells based on the national estimates for all wells. (Because the five domains *are not mutually exclusive*, and because they *do not exhaust* all categories of wells in the United States, the domain estimates in Exhibits 6-22 through 6-28 do not sum to the national estimates.) The breakdown of CWS wells and rural domestic wells by the Survey's domains of interest is shown in Exhibit 6-22, which indicates that the following percentages of rural domestic wells were located in the listed domains:

- about 11.0% (1,160,000) are located in counties with high pesticide use:
- approximately 27.3% (2,870,000) are located in counties with high ground-water vulnerability;
- about 35.1% (3,690,000) are located in "cropped and vulnerable" county subregions; and
- about 3.3% (342,000) are located in counties having high pesticide use and ground-water vulnerability.

These estimates are the basis for preparing the results of the five domain estimates for detected analytes and well characteristics discussed below. Use caution when trying to compare drinking water wells from the different domains. The confidence intervals do not account for possible relationships among variables or domains and in addition the domains are not independent. Therefore, trying to conclude that estimates in different domains are different is very difficult without conducting additional statistical tests. Statistical tests that account for relationships among variables will be conducted in the Phase II report.

Exhibit 6-22
Estimated Number and Percent of Community Water System Wells and Rural Domestic Wells Belonging to Domains of Interest[a]

Domain Description	Estimated Number	95% Confidence Interval (lower - upper)	Estimated Percent	95% Confidence Interval (lower - upper)
Community water system wells:	94,600	(90,900 - 98,300)	100.0	N/A
In counties having the highest average vulnerability	20,800	(19,800 - 21,800)	22.0	(20.8 - 23.2)
Rural domestic wells:	10,500,000		100	
In counties with highest average pesticide use	1,160,000	(831,000 - 1,480,000)	11.0	(7.9 - 14.1)
In counties with highest average vulnerability	2,870,000	(2,380,000 - 3,370,000)	27.3	(22.7 - 32.0)
In "cropped and vulnerable" county subregions	3,690,000	(2,890,000 - 4,490,000)	35.1	(27.5 - 42.8)
In counties having the highest average pesticide use and ground-water vulnerability	342,000	(223,000 - 461,000)	3.3	(2.1 - 4.4)

[a] The five domains are not mutually exclusive, and because they do not exhaust all categories of wells, the domain estimates do not sum to the national estimates. Use caution when trying to compare drinking water wells from the different domains. The confidence intervals do not account for possible relationships among variables or domains and in addition the domains are not independent.

6.5.2 Estimates for Detected Analytes

This section presents estimates for the various domains (subgroups) of special interest in the Survey. National estimates for community water system wells and rural domestic wells are presented for ease of comparison. Exhibit 6-23, which shows the estimated number and percent of wells by domain containing concentrations of nitrate above health-based standards, indicates that in general lower proportions of rural domestic wells containing nitrate are found in domains with high pesticide use. The following exhibits provide information about the subgroup of interest:

- Estimated number and percent of wells by domain containing concentrations above MRLs of at least one pesticide (Exhibit 6-24);
- Estimated number and percent of wells by domain containing concentrations above health-based standards of at least one pesticide (Exhibit 6-25);
- Estimated number and percent of wells by domain containing DCPA acid metabolites (Exhibit 6-26);
- Estimated number and percent of wells by domain containing atrazine (Exhibit 6-27); and
- Estimates, given by the 95% upper confidence bound of the maximum number of wells by domain containing concentrations of pesticides above the MRLs for pesticides not found in the Survey (Exhibit 6-28).

Exhibit 6-23

Estimated Number and Percent of Wells By Domain Containing Nitrate Detections and Nitrate Above Health-Based Standards[a]

Domain Description	Detected				Nitrate Estimate Above MCL/HAL				Concentration (ppm)[b]		
	Estimated Number	95% C.I. (lower - upper)	Estimated Percent	95% C.I. (lower - upper)	Estimated Number	95% C.I. (lower - upper)	Estimated Percent	95% C.I. (lower - upper)	MRL	Median	Max
CWS wells nationally:	49,300	(45,300 - 53,300)	52.1	(48.0 - 56.3)	1,130	(370 - 2,800)	1.2	(0.4 - 2.7)	0.15	1.8	13
In counties having the highest average vulnerability	7,830	(6,990 - 8,670)	36.7	(32.1 - 41.3)	0	(0 - 430)	0.0	(0.0 - 2.0)	0.15	1.4	8.4
Rural domestic wells nationally:	5,990,000	(5,280,000 - 6,700,000)	57.0	(50.3 - 63.8)	224,000	(122,000 - 484,000)	2.4	(1.3 - 4.4)	0.15	1.8	120
In counties with highest average pesticide use	313,000	(158,000 - 467,000)	27.0	(14.8 - 39.2)	60,100	(23,300 - 124,000)	5.2	(2.0 - 10.7)	0.15	3.4	120
In counties with highest average vulnerability	1,220,000	(738,000 - 1,690,000)	46.8	(30.0 - 63.6)	60,400	(12,100 - 176,000)	2.1	(0.4 - 6.1)	0.15	1.7	30
In "cropped and vulnerable" county subregions	1,950,000	(1,420,000 - 2,480,000)	52.8	(45.0 - 60.6)	147,000	(59,000 - 302,000)	4.0	(1.6 - 8.2)	0.15	2.2	35
In counties having the highest average pesticide use and ground-water vulnerability	136,000	(19,000 - 253,000)	39.7	(12.8 - 66.7)	26,400	(8,000 - 61,100)	7.7	(2.3 - 17.8)	0.15	3.3	30

[a] The five domains are not mutually exclusive and because they do not exhaust all categories of wells in the United States, the domain estimates do not sum to the national estimates. Use caution when trying to compare drinking water wells from the different domains. The confidence intervals do not account for possible relationships among variables or domains and in addition the domains are not independent. The Maximum Contaminant Level and Health Advisory Level for nitrate are both 10 mg/L.

[b] Median and maximum concentrations are based on laboratory data and have not been weighted to represent all wells in the U.S.

Exhibit 6-24
Estimated Number and Percent of Wells By Domain Containing at Least One Pesticide[a]

Domain Description	Estimated Number	95% Confidence Interval (lower - upper)	Estimated Percent	95% Confidence Interval (lower - upper)[b]
Community water system wells:	9,850	(6,330 - 13,400)	10.4	(6.8 - 14.1)
In counties having the highest average vulnerability	1,930	(1,200 - 2,670)	9.3	(5.8 - 12.9)
Rural domestic wells:	446,000	(246,000 - 647,000)	4.2	(2.3 - 6.2)
In counties with highest average pesticide use	41,100	(2,980 - 79,200)	3.6	(0.2 - 6.9)
In counties with highest average vulnerability	79,700	(9,260 - 150,000)	2.8	(0.4 - 5.1)
In "cropped and vulnerable" county subregions	202,000	(37,600 - 367,000)	5.5	(0.9 - 10.1)
In counties having the highest average pesticide use and ground-water vulnerability	4,820	(59 - 29,900)	1.4	(<0.1 - 8.8)

[a] The five domains are not mutually exclusive and because they do not exhaust all categories of wells in the United States the domain estimates do not sum to the national estimates. Use caution when trying to compare drinking water wells from the different domains. The confidence intervals do not account for possible relationships among variables or domains and in addition the domains are not independent.

[b] Numbers between zero and 0.05 are reported as less than 0.1 (<0.1).

Exhibit 6-25

Estimated Number and Percent of Wells By Domain Containing Concentrations Above Health-Based Standards of at Least One Pesticide[a]

Domain Description	Pesticides Above MCLs/HALs			
	Estimated Number	95% Confidence Interval (lower - upper)	Estimated Percent	95% Confidence Interval (lower - upper)[b]
Community water system wells:	0	(0 - 750)	0.0	(0.0 - 0.6)
In counties having the highest average vulnerability	0	(0 - 430)	0.0	(0.0 - 2.0)
Rural domestic wells:	60,900	(9,430 - 199,000)	0.6	(0.1 - 1.9)
In counties with highest average pesticide use	3,140	(1 - 40,400)	0.3	(<0.1 - 3.5)
In counties with highest average vulnerability	6,280	(1 - 88,100)	0.2	(<0.1 - 3.1)
In "cropped and vulnerable" county subregions	3,140	(1 - 87,300)	0.1	(<0.1 - 2.4)
In counties having the highest average pesticide use and ground-water vulnerability	0	(0 - 21,600)	0.0	(0.0 - 6.3)

[a] The five domains are not mutually exclusive and because they do not exhaust all categories of wells in the United States the domain estimates do not sum to the national estimates. Use caution when trying to compare drinking water wells from the different domains. The confidence intervals do not account for possible relationships among variables or domains and in addition the domains are not independent. This estimate is based only on the pesticides that have an associated MCL or HAL.

[b] Numbers between zero and 0.05 are reported as less than 0.1 (<0.1).

Exhibit 6-26
Estimated Number and Percent of Wells By Domain Containing DCPA Acid Metabolites[a]

Domain Description	Detected			
	Estimated Number	95% Confidence Interval (lower - upper)	Estimated Percent	95% Confidence Interval (lower - upper)[b]
Community water system wells:	6,010	(3,170 - 8,840)	6.4	(3.4 - 9.3)
In counties having the highest average vulnerability	1,390	(790 - 19,800)	6.7	(3.8 - 9.6)
Rural domestic wells:	264,000	(129,000 - 477,000)	2.5	(1.2 - 4.5)
In counties with highest average pesticide use	9,150	(210 - 51,000)	0.8	(<0.1 - 4.4)
In counties with highest average vulnerability	42,700	(5,420 - 149,000)	1.5	(0.2 - 5.2)
In "cropped and vulnerable" county subregions	145,000	(56,700 - 300,000)	3.9	(1.5 - 8.1)
In counties having the highest average pesticide use and ground-water vulnerability	0	(0 - 21,600)	0.0	(0.0 - 6.3)

[a] The five domains are not mutually exclusive and because they do not exhaust all categories of wells in the United States, the domain estimates do not sum to the national estimates. Use caution when trying to compare drinking water wells from the different domains. The confidence intervals do not account for possible relationships among variables or domains and in addition the domains are not independent.

[b] Numbers between zero and 0.05 are reported as less than 0.1 (<0.1).

Exhibit 6-27
Estimated Number and Percent of Wells By Domain Containing Atrazine[a]

Domain Description	Detected			
	Estimated Number	95% Confidence Interval (lower - upper)	Estimated Percent	95% Confidence Interval (lower - upper)[b]
Community water system wells:	1,570	(420 - 2,710)	1.7	(0.5 - 2.9)
In counties having the highest average vulnerability	83	(1 - 610)	0.4	(<0.1 - 2.9)
Rural domestic wells:	70,800	(17,900 - 189,000)	0.7	(0.2 - 1.8)
In counties with highest average pesticide use	21,600	(3,220 - 70,900)	1.9	(0.3 - 6.1)
In counties with highest average vulnerability	19,500	(400 - 112,000)	0.7	(<0.1 - 3.9)
In "cropped and vulnerable" county subregions	55,400	(6,120 - 105,000)	1.5	(0.2 - 7.8)
In counties having the highest average pesticide use and ground-water vulnerability	4,820	(59 - 29,900)	1.4	(<0.1 - 8.8)

[a] The five domains are not mutually exclusive and because they do not exhaust all categories of wells in the United States, the domain estimates do not sum to the national estimates. Use caution when trying to compare drinking water wells from the different domains. The confidence intervals do not account for possible relationships among variables or domains and in addition the domains are not independent.

[b] Numbers between zero and 0.05 are reported as less than 0.1 (<0.1).

Exhibit 6-28

Upper Bound Estimates of the Number of Wells By Domain Containing Pesticides Not Found in the Survey[a]

Domain Description	Estimated Number	Estimated Percent
Community water system wells:	750	0.8
In counties having the highest average vulnerability	430	2.0
Rural domestic wells:	83,100	0.8
In counties with highest average pesticide use	31,600	2.7
In counties with highest average vulnerability	69,100	2.4
In "cropped and vulnerable" county subregions	74,000	2.0
In counties having the highest average pesticide use and ground-water vulnerability	21,600	6.3

[a] The five domains are not mutually exclusive and because they do not exhaust all categories of wells in the United States, the domain estimates do not sum to the national estimates. The upper bound estimates presented are 95% upper confidence bounds based on the binomial distribution where the estimated proportion is zero. For further details see Section B6.4 of Appendix B.

Some items of interest for these exhibits include:

- About 36.7% of CWS wells located in counties with high ground-water vulnerability contain detectable levels of nitrate (Exhibit 6-23);
- About 57.0% of rural domestic wells nationally contain detectable levels of nitrate; about 27.0% of rural domestic wells in counties with high pesticide use recorded nitrate detections (Exhibit 6-23);
- Approximately 5.5% of rural domestic wells in "cropped and vulnerable" county subregions contain concentrations of at least one pesticide; about 1.4% in counties with high pesticide use and ground-water vulnerability (Exhibit 6-24);
- No more than 0.3% of rural domestic wells in the four domains of special interest contain pesticide concentrations above health-based standards for those with MCLs and HALs (Exhibit 6-25);
- The estimated percent of rural domestic wells containing DCPA acid metabolites was no more than 2.5% in all domains except in the "cropped and vulnerable" county subregions domain (3.9%) (Exhibit 6-26);
- The estimated percent of wells containing atrazine was less than 2% in all domains (Exhibit 6-27); and

- For analytes not detected by the NPS, the maximum estimated percent of wells containing pesticides above the analytical detection limits set in the Survey ranged from 2.0% to 6.3% for the five domains of special interest (Exhibit 6-28).

Well Characteristics

The Survey sought data for CWS wells in counties with high ground-water vulnerability; about 22.0% of CWS wells are located in counties with high ground-water vulnerability. Detailed compilations of the questionnaire results are provided in Appendix D, with indications of the particular questionnaire(s) and question(s) from which the data are compiled. Estimates for well characteristics in counties with high ground-water vulnerability were similar to the national estimates for the CWS survey.

The Survey also identified four domains of rural domestic wells of particular interest. These additional domains included rural domestic wells in counties: with highest pesticide use; highest average ground-water vulnerability; highest average pesticide use and ground-water vulnerability; and "cropped and vulnerable" county subregions. For wells in counties with high pesticide use, questionnaire items relevant to that domain which differ substantially from the national estimates include "property farmed" (about 24.8% in high pesticide use counties versus about 11.7% nationally); and "crops farmed within 1/2 mile of the well in the last 3 years" (about 89.8% versus about 66.2% nationally).

For the domains corresponding to counties with high vulnerability and "cropped and vulnerable" county subregions, estimates of parameters related to vulnerability were similar to the national estimates presented in Section 6.4.2, although 79.7% of wells in "cropped and vulnerable" county subregions had crops farmed within ½ mile of the well compared to 66.2% nationally.

For wells in the high ground-water vulnerability and high pesticide use counties, factors showing important differences from all rural domestic wells may exist, but the large confidence intervals for the data make comparisons too uncertain to be presented.

6.6 Additional Analyses to Appear in Phase II Report

The focus of Chapter 6 has been on presenting estimates of the number and proportion of wells in the United States and in the five domains of special interest that contain detectable levels of nitrate and pesticides. In addition, this chapter discussed summary statistics on key questionnaire items such as farm and non-farm pesticide use on the property and well characteristics. The purpose of the NPS Phase II Report is to present the findings of studies of interrelationships among data gathered in the questionnaires that may affect detection rates, concentrations (e.g., well depth, well age, and well construction), and analyte detections. Section 6.6.1 describes some of the relational analyses that will be conducted. In addition, the Phase II report will expand upon results of the analysis EPA conducted to determine if the Survey's results were affected by seasonal variations in the time when the water samples were obtained. Section 6.6.2 describes a preliminary analysis of seasonal variation.

6.6.1 Relational Analyses

This section discusses the statistical studies that are planned for the Phase II Report. Numerous computerized databases have been compiled from the questionnaires and other sources for the Survey to determine the association of well contamination with such factors as fertilizer and pesticide use on the property, within one-half mile of the well, and within the county; and ground-water vulnerability characteristics including depth to ground water, recharge, aquifer media, soil media, topography, impact of unsaturated zone, and hydraulic conductivity. The Phase II Report will analyze the questionnaire databases, the first-stage and second-stage DRASTIC stratification scoring results, nitrogen fertilizer and pesticide sales, and the Survey analytical results, to investigate the potential causes and consequences of pesticide residues in drinking water wells.

The Phase II Report will investigate possible reasons why the Survey detected the presence of no more than 17 chemicals of the 127 studied. The Survey was designed to test approximately 560 CWS wells and 750 rural domestic wells for one or more pesticides. A different design with a larger sample size and different analytical methods for each pesticide would be necessary to assure a greater chance of detection of any given chemical. The Survey results may be a reflection of the detection limits associated with the Survey's analytical methods. The NPS Minimum Reporting Limits were established at relatively high levels above instrument detection limits, and were backed up by stringent confirmation requirements. These procedures reduced the number of "false positives" (i.e., reports of analyte detections that were not confirmed) and reduced the cost of laboratory analysis, but may also have led to a lower number of detections for specific NPS analytes. Second, certain analytes may have been present in the wells that were sampled, but were not detected because of either their instability (6 analytes) or the analytical methods were unreliable (9 analytes). That is, they may have transformed or deteriorated so rapidly that their presence was not detectable by the analytic methods used. As discussed in Chapter 4, fifteen analytes exhibit these characteristics. EPA conducted a number of analyte stability studies over the course of the Survey whose results will be reported and analyzed in Phase II. Finally, the process of survey selection for the wells to be sampled may have identified wells in locations where certain pesticides are relatively uncommon. The Phase II analysis will investigate further the effects of these factors.

Relational analyses will include a study of whether there is an association among questionnaire responses or between questionnaire responses and water quality. The hypotheses that might be tested include the following: Are there more analyte detections of chemicals associated with unconfined aquifers than with confined aquifers? Are nitrate detections associated with septic units on the property? Are there more analyte detections of chemicals associated with areas where irrigation is used? EPA is planning scientific investigations to:

- Determine the relationship between nitrate and pesticide detections;
- Determine the association among detections and well characteristics;
- Correlate DRASTIC subscores by individual factors (e.g., depth to ground water) with detections in rural domestic wells;
- Determine associations between pesticide use and pesticide detections in water samples;
- Prepare tables showing pesticide detections by county pesticide use estimates for specific analytes that were detected in the Survey;
- Prepare summary statistics, such as frequencies, of analytes detected in areas where crops with known associated pesticide use are grown;
- Conduct regression modeling for analytes with sufficient detections. These analyses will seek to identify significant relationships between variables that are not readily discernible from the demographic analyses presented in the Phase I Report. Regression modeling will include:
  - Stepwise multivariate regression analyses using all the relevant variables evaluated in the demographic analyses; and
  - Nonlinear (e.g., logistic) regression analyses on subsets of significant variables identified in the multivariate regression.

- Evaluate analytes with few detections by non-statistical review of all available data. Site-specific parameters that may be related to water sample findings will be evaluated. Data sources will include:
    - marginal comments from questionnaires made by interviewers to note special types of information;
    - records of conversations with samplers and owner/operators; and
    - analytical instrumentation detection capabilities.
- Compare NPS findings with other studies (e.g., Monsanto's National Alachlor Well Water Survey, selected state surveys, pesticides in ground water database).

6.6.2 Evaluation of the Impact of Seasonal Variation on National Estimates

In designing the Survey, EPA minimized the impact of seasonal variability in analyte detections that might occur as a function of the time of year or point in the agricultural growing season when the well water samples were obtained, i.e., more frequent or higher levels of concentrations might occur during particular seasons or months. The FIFRA Scientific Advisory Panel subpanel advised EPA in 1987 in its review of the Survey design that certain of the large number of factors affecting the presence of pesticides in drinking water wells could offset seasonal patterns of precipitation or pesticide use. The subpanel, therefore, encouraged EPA to develop practical approaches for minimizing the effect of seasonal variability, and EPA did so. The final Survey included allocation of individual well sites across the 22 month sampling period. Given the constraints of contract laboratory capacity, cost, and project schedules, EPA selected a method to assign the times of well water sampling randomly to specified two-week sampling intervals distributed across the full-scale sampling period through February 1990. Using this method, EPA sought to obtain data concerning seasonal variations in the presence of pesticides in drinking water wells, while minimizing the effect of the Survey's sampling schedule on the NPS results (see Section B5 of Appendix B for further details).

EPA's initial temporal analysis focused on national nitrate detections for both CWS wells and rural domestic wells. This approach was taken based on the large number of nitrate detections in comparison to all other analytes. EPA compared the proportion of nitrate detections in each temporal period (e.g., a month, or a season). Different seasonal groupings and different groupings of months across the two years of the Survey were studied.

Initial analyses of temporal effects were performed using chi-square tests for independence of Survey nitrate detections and various temporal variables. The temporal variables included monthly and various seasonal groupings. Initial analyses suggest differing results for CWS wells and rural domestic wells. Preliminary analyses suggest that there is no seasonal variation on a national basis for CWS wells. In other words, nitrate detections in CWS wells do not appear to occur more frequently during a specific month or season. In contrast, preliminary analyses for rural domestic wells suggest that more nitrate detections did occur during specific months of the year for rural domestic wells, in particular the summer and fall months of July through December. EPA subsequently performed similar temporal analyses for the detection of at least one pesticide nationally. The results of these analyses were similar in direction to those for nitrates, but not nearly as pronounced. Pesticide detections appear to have occurred at greater frequency in the latter months of 1988 in rural domestic wells only (there was no apparent effect for CWS wells).

If these initial preliminary indications of a seasonal effect for rural domestic wells is supported by more detailed scientific and statistical analysis in Phase II, a more complex analysis of the nitrate and pesticide data may be required. It appears, however, that this early indication of seasonal variability in the number of detections is not a function of EPA's sampling schedule, but is a result of a variety of factors that will require more detailed analysis in Phase II. A number of key questions will be investigated.

- Why is there an apparent temporal effect for rural domestic wells and not for CWS wells?
- How does the nitrate temporal effect compare to temporal effects for other analytes?
- Is the seasonal variation, if any, correlated with the stratification variables used in the Survey? and
- How does (any observed) seasonal variation affect conclusions that may be drawn about the frequency or proportion of wells containing pesticides or nitrate.

Conclusion

The findings and results described in this chapter conclude several years of intense activity by EPA to assess the problem of pesticides and nitrate in drinking water wells. Extensive statistical analysis, to be conducted with NPS data during Phase II, will provide additional findings to enhance the Agency's understanding of major factors that affect well water quality. Although more analysis is required, the Survey has produced several important products, described in Chapter 7, and several key findings presented here.

Three key points can be identified from the NPS results. First, low levels of nitrate occur in more than fifty percent of the nation's drinking water wells. Second, DCPA acid metabolites and atrazine were detected consistently in both community water system wells and rural domestic wells. Third, although several pesticides and nitrate were frequently detected in the nation's drinking water wells, most are below health-based levels and do not pose a risk to public health. These Survey results show that substantial numbers of wells, particularly rural domestic wells, could be affected by the presence of one or more pesticides or nitrate. This evidence of widespread migration of chemicals indicates that there is a need for continued attention to ground-water protection and additional analysis of the issue.

Pilot Study Reports. Several reports on the pilot study are available through the Office of Pesticide Programs Docket, including:

1. Final Report on the Management Systems Review of the Pilot Survey of Pesticide Contamination in Groundwater, Quality Assurance Management Staff, USEPA, 1987;
2. National Pesticide Survey Pilot Study Evaluation Summary Report, Office of Drinking Water and Office of Pesticide Programs, USEPA, 1987; and
3. National Pesticide Survey Pilot Evaluation Technical Report, R.E. Mason, L.L. Piper, W.J. Alexander, R.W. Pratt, S.K. Liddle, J.T. Lessler, M.C. Ganley, D.J. Munch, and G. Langner, RTI/7801/06-02F, 1987.

Scientific Advisory Panel Reports. The Federal Insecticide, Fungicide, and Rodenticide Act, Scientific Advisory Panel Subpanel prepared two reports, which are available for review at the Office of Pesticide Programs Docket.

1. Technical Review of the Preliminary Design of the National Survey of Pesticides in Ground Water -- Report of Subpanel Recommendations: October 9, 1985, Federal Insecticide, Fungicide, and Rodenticide Act Scientific Advisory Panel Subpanel; and
2. A Set of Scientific Issues Being Considered by the Agency in Connection with the National Pesticide Survey Pilot Study, October 9, 1987, Federal Insecticide, Fungicide, and Rodenticide Act, Scientific Advisory Panel Subpanel.

Survey Questionnaires. EPA developed several questionnaires to collect data necessary for the interpretation of NPS analytical results. The Agency administered questionnaires to determine whether randomly selected community water systems and domestic wells were eligible for NPS water sampling; record observations about the well location and the surrounding area; collect information from the owner/operator about the use and construction of the well sampled and use of non-farm and farm pesticide (e.g., volume of and location of application in relation to the well) on the property where the well was located; and gather information from local area experts about cropping, pesticide use, and industry locations within one-half mile of the well. The NPS questionnaires are provided in Appendix D.

Training Manuals. EPA prepared training manuals to instruct EPA, State, and regionally-based contractor personnel on sampling techniques and procedures, questionnaire administration, and communication protocols. The manuals were distributed during training workshops that were held from May 1988 through January 1990. The manuals are available for review at the EPA Office of Pesticide Programs Docket.

Analytical Methods. The NPS Analytical Methods Task Force identified six new methods, five of which are capable of evaluating multiple analytes (multi-residue methods) and two existing EPA analytic methods for use in the NPS as well as in future analysis of pesticides in water. The methods are listed in Exhibit 4-2, Chapter 4, and are available from the National Technical Information Service.

Chapter Seven: Survey Products

Introduction

This chapter briefly describes products that were developed during the National Pesticide Survey. These products were designed to facilitate the overall Survey planning and implementation activities and include documents, techniques, and procedures in the areas of: risk communication, techniques for characterizing pesticide use and ground water vulnerability, quality assurance, survey implementation procedures, and analytical methods. Information on the availability of each products also is provided in this chapter.

7.1 Survey Products

Health Advisories. A Health Advisory is a technical, scientific guidance document containing information on physicochemical properties, uses, chemical fate, health effects, treatment, and existing criteria and guidelines. EPA developed 99 technical Health Advisories for pesticides and nitrate. The Health Advisories can be obtained from the National Pesticide Telecommunications Network at (800) 858-4791.

Health Advisory Summaries. As part of EPA's effort to explain the health effects of exposure to pesticides and nitrate in non-technical language, the Agency prepared and distributed over 50 Health Advisory Summaries. EPA distributed Health Advisory Summaries immediately to the well owners and operators of sampled wells where pesticides or nitrate were found and to residents who might consume water from such wells. Copies of these summaries can be obtained from the National Pesticide Telecommunications Network at (800) 858-4791.

"Pesticides in Drinking Water Wells" Brochure. EPA prepared a "Pesticides in Drinking Water Wells" brochure, which provides an overview of the nature of pesticides and their possible effects in drinking water wells. A copy of this brochure can be obtained by contacting the EPA Safe Drinking Water Hotline at (800) 426-4791 or (202) 382-5533.

First Stage County Use and Vulnerability Scores. During the Survey design, EPA created data files on tape of pesticide use and overall DRASTIC score ratings for all 3,137 counties in the United States. The data tapes will be available through the Office of Pesticide Programs Docket (703) 557-2805. A technical document that explains which files are on the tape and provides information on how to access the data will accompany the tapes in the Docket.

Second Stage County Maps. Following the DRASTIC scoring process during the Survey design, NPS staff mapped each of the 90 Survey counties selected for rural domestic well sampling delineating the hydrogeologic settings, cropping areas, and associated vulnerability scores. An example of such a "cropped and vulnerable" map appears in Exhibit 2-9 of this report. The maps will be available for review in the Office of Pesticide Programs Docket.

Quality Assurance Project Plans. During planning and implementation of the Survey detailed plans were prepared outlining the oversight activities that would be undertaken to ensure that the Survey produced data of a known and useful quality. These quality assurance project plans provide specific information on the QA/QC requirements for each of the analytical and implementation activities. These plans are available from the National Technical Information Service in Springfield, Virginia, (703) 487-4650.

Domains of Interest	The seven subgroups of the entire population of drinking water wells about which the Survey was particularly interested in obtaining data. The seven domains of interest are (1) community water systems nationally; (2) community water systems in counties with the highest average ground-water vulnerability; (3) rural domestic wells nationally; (4) rural domestic wells in counties with the highest average pesticide use; (5) rural domestic wells in counties with the highest average ground-water vulnerability; (6) rural domestic wells in counties with the highest average pesticide use and ground-water vulnerability; and (7) rural domestic wells in "cropped and vulnerable" areas of counties.
DRASTIC	A classification system that attempts to provide a relative ranking of the vulnerability of ground-water to contamination. The letters in DRASTIC stand for features of the area around the well that may affect the movement of pesticides into ground water: (depth to water, recharge, aquifer media, soil media, topography, impact of the unsaturated aqueous zone between the soil media and water table, and conductivity of the aquifer). DRASTIC does not consider sources of the contamination or population affected. A DRASTIC score was computed for all of the counties in the United States as part of the Survey.
Drinking Water Well	A rural domestic well or a community water system well whose water is used primarily for human consumption (i.e., drinking, cooking, and bathing).
EPA Laboratory	One of two EPA laboratories that were chosen to manage contracts for the analytical laboratories, and perform referee analyses.
Estimated Detection Limit	The minimum concentration of an analyte that can be measured and reported with confidence that the analyte concentration is greater than zero.
Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)	Federal law first enacted in 1947 and administered by the EPA since 1970. Under FIFRA, EPA registers pesticide products and ensures that they will not present unreasonable risks to human health or the environment when used according to label directions.
Federal Reporting Data System (FRDS)	A data base maintained by EPA's Office of Drinking Water (ODW) that contains information on all public water supply systems in the United States. The FRDS was used as the sampling frame for selecting community water system wells for NPS water sampling and analysis.
Ground Water	Water found beneath the earth's surface contained in the interconnected pores and fractures of soils and geologic formations.
Ground-Water Vulnerability	The degree to which ground water in the area surrounding a well is sensitive to pesticide infiltration, based on an assessment of the hydrogeological makeup of an aquifer, such as depth of the water table, soil properties, and ground-water recharge rates.
Health Advisory	A technical and scientific guidance document prepared by EPA for many of the analytes included in the Survey. Each Advisory contains information on the analyte's physicochemical properties, uses, chemical fate, health effects, treatment, and existing criteria and guidelines. EPA also prepared non-technical Health Advisory Summaries based on the Health Advisories.

Glossary and List of Acronyms

Glossary

Active Ingredient	The specific chemical in a product that is biologically active against pest organisms.
Analyte	One of 127 chemicals that the Survey analytical methods were chosen or designed to identify. The Survey analytes include 101 pesticides, 25 pesticide degradates, and nitrate. Analytes were selected on the basis of expected leaching potential, occurrence in ground water, volume of use, and other considerations.
Analyte Stability Study	An analysis of a laboratory sample in which a known quantity of an analyte has been placed (a "spiked" sample). The sample is analyzed at a pre-determined time to assess the stability and recovery of the analyte.
Analytical Method	One of the eight chemical testing methods used to analyze Survey water samples. Six of the analytic methods were specifically developed for the NPS.
Carcinogen	A substance that is either known or suspected to cause cancer.
Community Water System (CWS)	A system of piped drinking water that either has at least 15 connections or serves at least 25 permanent residents. To be eligible for the NPS, a system had to have at least one operable well (at the time of sampling) supplying drinking water.
Confidence Interval	The upper and lower limits around an estimated value within which the actual population value is expected to fall. The confidence interval is stated as a specified level, such as 95%, of confidence. For the NPS, estimates for wells throughout the United States, based on analysis of results for the NPS sample of wells, are given with a 95% confidence interval, indicating the upper and lower limits that EPA is reasonably confident contain the actual detection rate.
Contaminant	Any substance such as a chemical, ion, radionuclide, synthetic organic compound, microorganism, waste, or other substance that occurs in water causing it to be impure. Contaminated water does not necessarily pose a health risk if the concentration of the contaminant does not exceed acceptable drinking water standards.
Contamination	The direct or indirect introduction of any contaminant into ground water caused in whole or in part by human activities.
Contract Laboratory	One of the five laboratories hired to analyze Survey water samples. The laboratories performed different analytic methods. EPA laboratories performed referee and confirmation analyses to verify the results of the contract laboratories.
Cropped and Vulnerable	Sub-county areas specified for the rural domestic well survey that have high ground-water vulnerability and greater than 25 percent of the land area used for agricultural production or medium ground-water vulnerability and greater than 50 percent of the land area used for agricultural production.
Degradate	The product of the chemical or biological breakdown of a complex compound into simpler compounds. See Pesticide Degradate.

National Pesticide Survey Pilot Study	The preliminary study for the NPS conducted in 1987 in the States of California, Minnesota, and Mississippi. The pilot study determined whether any changes in the proposed Survey design were necessary or advisable prior to the implementation of the full-scale Survey. The pilot program sampled approximately 50 rural domestic and community water system wells.
National Pesticide Telecommunications Network	A toll-free information service that answers inquiries on the health effects of pesticides and pesticide poisonings. This service operates 24 hours a day and can be reached at 1-800-858-7378.
Nitrate (NO_3^-)	An oxidized form of nitrogen that is an important plant nutrient and inorganic fertilizer. The major sources of nitrate are septic systems, animal feed lots, agricultural fertilizers, manured fields, industrial waste waters, sanitary landfills, and garbage dumps. Nitrate also occurs naturally in ground water. The Survey analyzed water samples for the combined presence of nitrate and nitrite, measured as nitrogen (N).
Nitrite (NO_2^-)	A form of nitrogen that is less oxidized than nitrate. Nitrite is a relatively unstable transitional form between nitrate and ammonium.
Office of Drinking Water (ODW)	The EPA office, under the management of the Office of Water, that is primarily responsible for implementing the Safe Drinking Water Act (SDWA). The Office of Drinking Water jointly conducted the NPS with the Office of Pesticide Programs.
Office of Pesticide Programs (OPP)	The EPA office, under the management of the Office of Pesticides and Toxic Substances, that is primarily responsible for implementing the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). The Office of Pesticide Programs jointly conducted the NPS with the Office of Drinking Water.
Organic Compound	Natural or synthetic chemical containing carbon.
Parts per billion (PPB)	A measure that corresponds to one part pesticide in one billion parts of water. $PPB = \frac{\text{Weight of material}}{\text{Total wt. of gas, liquid, or solid}} \times 1{,}000{,}000{,}000$
Parts per million (PPM)	A measure that corresponds to one part nitrate in one million parts of water. $PPM = \frac{\text{Weight of material}}{\text{Total wt. of gas, liquid, or solid}} \times 1{,}000{,}000$
Pesticide	Chemical substance used to destroy, control, or repel undesirable organisms which may include plants, insects, fungi, nematodes, rodents, predators, or microorganisms.
Pesticide Degradate	A generic term that includes breakdown products of a pesticide active ingredient resulting from biological processes (i.e., metabolites) and chemical processes (i.e., hydrolysis, photolysis, photooxidation). See Degradate.
Pesticide Metabolite	A product of biological processes (e.g., metabolism, or the chemical changes in living cells) of a pesticide active ingredient by microorganisms, plants, or animals.

Health Advisory Level (HAL)	The maximum concentration of a contaminant in water that may safely be consumed over a specific time period. EPA sets HALs for short-term exposures, such as one day and ten days, and longer-term exposures of greater than ten days up to several years, and over a lifetime. A pesticide's HAL is based on health effects (other than cancer) that were found in humans or in animals given high doses of the pesticide in laboratory studies. For pesticides believed to cause cancer, EPA does not calculate a Lifetime HAL. Instead, EPA calculates the increased risks of cancer that are associated with different concentrations and exposures to the pesticide.
Health Advisory Summary	A one-page summary prepared by EPA for many of the analytes included in the Survey. These summaries provide concise information on possible health effects of these chemicals and actions that may be taken to ensure a safe drinking water supply. EPA distributed these summaries to the owners, residents, and operators of sampled Survey wells in which analytes were detected.
Herbicide	A pesticide used to limit or inhibit plant growth.
Human Health Risk	The probability that a given exposure or series of exposures will damage the health of individuals experiencing the exposures.
Hydrology	The science dealing with the properties, distribution, and circulation of water on the land surface, in the soil, and in underlying rock formations.
Insecticide	A pesticide used to control insects.
Leaching	The downward transport through the soil by percolating water of dissolved or suspended minerals, fertilizers, pesticides, and other substances. A chemical's solubility, the soil texture, and the amount and timing of water applied to the soil (as in irrigation, rainfall, or heavy runoff) all contribute to the rate of leaching.
Maximum Contaminant Level (MCL)	The maximum permissible level of a contaminant in water that is delivered to any user of a public water system (established by the Safe Drinking Water Act (SDWA)).
Method Blank	A portion of reagent water analyzed as if it were a sample.
Micrograms per Liter (µg/L)	One-millionth of a gram of a substance per liter of water, commonly referred to as parts per billion. This unit of measurement was used for pesticides and pesticide degradates in water samples during the Survey.
Milligrams per Liter (mg/L)	One-thousandth of a gram of a substance per liter of water, commonly referred to as parts per million. This unit of measurement was used for nitrate in water samples during the Survey.
Minimum Quantification Limit (MQL)	The lowest concentration of an analyte in a sample that could be reliably measured and reported as a detection with a measured concentration.
Minimum Reporting Limit (MRL)	The lowest concentration of an analyte that could reliably be reported as a detection of that analyte, established as one-half the MQL. Analytes detected at a concentration between one-half the MQL and the MQL were reported as detected, without a measured concentration.

Scientific Advisory Panel (SAP)	A panel of scientists created under the authority of FIFRA to advise the EPA on scientific issues related to the assessment of risks posed by pesticides. A special subpanel of the SAP reviewed the Survey design in 1985 and in 1987 reviewed technical issues such as data collection options, well selection methods, temporal variation, and analyte instability.
Septic System	A sewage system composed of both a septic tank and septic field. The septic tank is an underground watertight container made of durable material through which sewage flows very slowly and in which solids separate from the liquid to be decomposed or broken down by bacterial action. The septic field is the area through which the sewage liquid passes and in which it is cleaned through physical filtering by soils, biodegradation, and evaporation.
Spiked Sample	A water sample to which a known quantity of a pesticide has been added so that the accuracy of the laboratory analyses can be determined.
Surface Water	Water found on the land surface in streams, ponds, marshes, lakes, or other fresh water sources.
Synthetic Organic Compound (SOC)	Man-made organic compound, not naturally found in ground water.
Temporal Variability	Seasonal fluctuations in weather conditions and pesticide use that may affect the presence of pesticides in ground water and may potentially bias Survey sampling. This problem was minimized by randomly allocating selected wells to specified two-week periods within each strata across the two year sampling period.
Volatile Organic Compound (VOC)	An organic compound that evaporates (volatilizes) readily into the atmosphere and is highly mobile in ground water.
Water Table	The top of an unconfined (unpressurized) aquifer, below which the void spaces resulting from the granular texture or fractures of earthen material are saturated with water.
Well Casing	Materials such as concrete, piping, metal, and stone that line and support a well and prevent it from collapsing.

Public Water Supply Identification Number (PWSID)	The unique identifying number given to public water systems in the Federal Reporting Data System (FRDS) that was used when statistically selecting community water systems for the NPS.
Quality Assurance (QA)	Oversight activities performed by EPA and its contractors to maintain quality control standards and to ensure compliance with the standard operating procedures for conducting well sampling, laboratory analysis, and processing Survey questionnaires.
Quality Control (QC)	Monitoring activities performed by EPA and its contractors to ensure that sampling, data collection, and laboratory procedures are properly conducted and meet specified performance standards.
Random Sample	A method of statistical sampling that ensures each member of the population has the same chance of being chosen.
Rapid Reporting Level	A level of pesticide or nitrate presence detected by the Survey laboratories that warranted immediate contact with the well owner/operator. Rapid reporting occurred if the measured detection equalled or exceeded EPA's Lifetime Health Advisory Levels for the detected analyte.
Raw Water Sample	A water sample gathered prior to treatment of any kind.
Reagent Water	Water used in the laboratory quality assurance/quality control procedures that is treated to remove any contaminant so it will not be observed at or above the estimated detection limit of any analyte.
Relational Analysis	Any of the various types of statistical methods used to estimate the correlation or relationship between variables in a given population.
Rural Domestic Well	A drinking water well that supplies an occupied private household located in rural areas of the United States, except for wells located on government reservations. The Census Bureau defines rural areas as households outside of incorporated or unincorporated places with a population of 2,500 or more and outside of urban areas. To be eligible for the Survey, the NPS required that the well be used for human consumption (i.e., drinking, cooking, bathing).
Safe Drinking Water Act (SDWA)	A law passed in 1974 and administered by EPA that establishes national standards for drinking water to provide a safe and wholesome water supply from both surface and ground-water sources.
Safe Drinking Water Hotline	A toll-free hotline established by EPA in July 1987 to handle requests for information on drinking water issues, including the NPS. The hotline can be reached at 1-800-426-4791 (in Washington, D.C. at (202) 382-5533) and is operated Monday through Friday, 8:30 to 4:30 eastern standard time.
Sample Blank	Water samples that were shipped to analytical laboratories for analysis and compared to the analytical results of NPS well water samples to ensure that the analytical methods were accurate.

NPTN	National Pesticide Survey Telecommunications Network
NTIS	National Technical Information Service
ODW	Office of Drinking Water
OPP	Office of Pesticide Programs
PE	Performance Evaluation
PIC	Public Information Center
PPB	Parts per billion
PPM	Parts per million
PWSIN	Public Water Supply Identification Number
QA	Quality Assurance
QAC	Quality Assurance Coordinator
QAMS	Quality Assurance Management Staff
QAO	Quality Assurance Officer
QAPjP	Quality Assurance Project Plan
QAPP	Quality Assurance Program Plan
QA/QC	Quality Assurance/Quality Control
QC	Quality Control
RDD	Random Digit Dialing
SAP	Scientific Advisory Panel
SCS	Sampling Control System
SDWA	Safe Drinking Water Act
SOC	Synthetic Organic Compound
SOP	Standard operating procedure
TSA	Technical System Audit
TSD	Technical Support Division
USDA	United States Department of Agriculture
USGS	United States Geologic Survey
VOC	Volatile Organic Compound

List of Acronyms

ADQ	Audits of Data Quality
CATI	Computer Assisted Telephone Interviews
CCS	Communications Control System
CWS	Community Water System
DCS	Document Control System
DQO	Data Quality Objective
DRASTIC	Depth/Recharge/Aquifer/Soil/Topography/Impact/Conductivity
EDL	Estimated Detection Limit
EMSL-CI	Environmental Monitoring and Systems Laboratory - Cincinnati
EPA	Environmental Protection Agency
ES&E	Environmental Science and Engineering
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FRDS	Federal Reporting Data System
GC	Gas chromatography
GC/MS	Gas chromatography/mass spectrometry
HAL	Health Advisory Level
HPLC	High pressure liquid chromatography
IOC	Inorganic compound
LOQ	Level of quantification
MCL	Maximum contaminant level
Mg/L	Milligrams per Liter
µg/L	Micrograms per Liter
MQL	Minimum quantification limit
MRL	Minimum reporting limit
ND	Non-detected
NPS	National Pesticide Survey
NPSIS	National Pesticide Survey Information System

National Pesticide Survey

Appendix A: Background

Appendix A: Background

A1 Introduction

The National Survey of Pesticides in Drinking Water Wells originated in 1984 and is one of the most complex surveys ever conducted by EPA. This appendix reviews the background, context, and objectives of the Survey; discusses the management and planning of the Survey up to the end of 1987, when a pilot study was successfully completed and its lessons incorporated into the Survey design; and records some of the major substantive issues and decisions encountered in the course of planning the Survey through the completion of the pilot survey. Appendix C discusses management and implementation of the Survey from the completion of the pilot study to completion of the full scale Survey.

Appreciation of the fragility and importance of ground water is a recent phenomenon. Ground water once was thought to be protected from pesticide contamination by impervious layers of subsoil, rock, and clay, and by chemical degradation processes in and on the soil. One of the first steps in dismantling this long-held belief was the discovery of the pesticide dibromochloropropane (DBCP) in about 2,500 wells in California. DBCP was soon found in ground water in four other States as well. Another pesticide, aldicarb, was found in 1979 in wells on Long Island, New York, and subsequently in Wisconsin and 11 other States. The discoveries of ethylene dibromide (EDB) in wells in California, Georgia, and other States in 1982-1983 raised concerns to a new level.

By the mid-1980s, there were indications of a larger problem of pesticides in ground water. By 1987, at least 17 pesticides had been found in ground water in 23 States.[1] Studies of pesticides in ground water were undertaken by the States of California, Florida, Maryland, Minnesota, New York, Washington, and Wisconsin, among others.

Most of these studies, however, were limited to a small number of pesticides and specific geographic areas and did not attempt a comprehensive nationwide assessment. Furthermore, not all States were active in monitoring for pesticides. Finally, in selecting wells for sampling, most State surveys did not use a statistical method that would allow the results to be extrapolated to a larger population.

EPA undertook the National Pesticide Survey (NPS) in response to the need for nationwide information on pesticides in drinking water. The Survey was predicated on the concern that agricultural chemicals, both pesticides and fertilizers, might be playing a significant role in ground-water contamination and that there was cause for concern for the quality of ground water as an irreplaceable drinking water source. A particularly disturbing realization was that one of the major sources of the presence of agricultural chemicals in ground water might be the normal, approved use of these chemicals. From a health perspective, the pervasiveness, toxicity, and persistence of many pesticides in the environment were of concern. A number of pesticides are known or suspected to cause a variety of adverse health effects, ranging from eye and skin irritation to cancer. With growing public concern about the health and environmental implications of chemicals in ground water, EPA issued a ground-water protection strategy in 1984, and began the development of a longer-term effort, referred to as the Pesticides in Ground Water Strategy.

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[1] Cohen, S.Z., C. Eiden, and M.N. Lorber, "Monitoring Ground Water for Pesticides in the U.S.," in Evaluation of Pesticides in Ground Water, ACS Symposium Series No. 315, ed. by W.Y. Garner, R.C. Honeycutt, and H.N. Nigg, American Chemical Society, Washington, D.C., 1986. See also: Pesticides in Ground Water: Background Document, U.S. EPA, Office of Ground Water Protection, May 1986.

The National Pesticide Survey is a major component of the Agency's overall effort to understand and characterize the problem of agricultural chemicals in ground water. The National Pesticide Survey was undertaken by EPA's Office of Pesticide Programs (OPP) and Office of Drinking Water (ODW) with two principal objectives in mind: (1) to determine the frequency and concentration of pesticides, pesticide degradates, and nitrate in the drinking water wells of the nation; and (2) to improve our understanding of how the presence of these substances is associated with patterns of agricultural pesticide usage and the vulnerability of ground water to pollution. Survey information was collected to help support the development, evaluation and enforcement of regulations and guidance for drinking water and pesticides under the Safe Drinking Water Act (SDWA) (Sections 1442 and 1445) and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (Section 20C). Exhibit A-1 provides a list of the uses of NPS data that were expected at the time.

With adequate Survey information on the presence of different pesticides in wells around the country, EPA can better design its regulatory programs to target pesticides of concern. Pesticides shown to pose potential hazards by their ability to leach into ground water could be subject to a range of further regulatory actions under FIFRA, including changes in label directions, use restrictions, or suspension or cancellation of a pesticide's registration. The Agency also intended to use information from the Survey to implement SDWA requirements. New maximum contaminant levels and monitoring requirements could be proposed for pesticides shown to pose a hazard in public drinking water.

A2 Management and Planning of NPS

A2.1 Early Proposals: 1979-1984

A study of pesticides in ground water was first discussed at EPA in a September 1979 OPP memorandum that outlined criteria for selecting pesticides and soils.[2] The original focal points of interest were whether pesticides are leaching from the soil surface to aquifers, and whether there are any predictive tools that could warn of such contamination problems. By December 1979, a list of 26 candidate pesticides had been developed for the proposed study, based on their physical properties, soil mobility, persistence, usage on crops, and human and animal toxicity.

The study was not funded at the time, but the proposal resurfaced when EPA suspended use of a soil fumigant, ethylene dibromide (EDB) in September 1983. During 1984, OPP and ODW agreed on a joint study, officially laid out in a memorandum of agreement between the two offices. A major issue was whether to limit the study only to ground water (favored by OPP and the option ultimately taken) or also to include surface water (favored by ODW).

Full-scale planning of a ground-water study was authorized in August 1984 in a joint memorandum from the Directors of ODW and OPP. One representative each from ODW and OPP were designated as coordinators of the management work plan. Thirteen task groups were set up, including an analyte selection workgroup, an analytical methods workgroup, a health advisory workgroup, a hydrogeologic workgroup, a pesticide-use workgroup, a quality assurance workgroup, a State liaison workgroup, a sampling workgroup, and a data management workgroup. EPA contracted with Research Triangle Institute to do the statistical design of the Survey.

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[2] More information on the early years of the survey and an extensive bibliography may be obtained from the report, National Survey of Pesticides in Drinking Water Wells: A Review of the Planning Process and The Data Quality Objectives, by Monica Nees and Cynthia Salmons, Contract No. 68-01-7350, Research Triangle Institute, Research Triangle Park, NC, July 6, 1987.

Exhibit A-1
Anticipated Uses of National Pesticide Survey Data

- Enhance EPA's ability to meet the growing demands for accurate data on the presence of pesticides in drinking water wells.
- Identify pesticide compounds which occur at levels of health concern or with sufficient frequency to be considered high priority candidates for regulation through the maximum contaminant level (MCL) process under SDWA.
- Identify the range of pesticide concentrations found in community water systems, so that the feasibility of drinking water treatment can be assessed.
- Identify and examine the relationship of pesticide contamination to ground-water vulnerability and pesticide usage in order to help direct compliance monitoring requirements for community water systems.
- Facilitate regulatory impact analyses by building an adequate data base on the distribution of pesticide levels in drinking water.
- Develop working relationships with the States to facilitate implementation of drinking water programs and to build State programs relating to pesticides.
- Promote coordinated ongoing monitoring programs with States and USGS, building on the NPS data base.
- Determine the scope of the national problem of pesticides in drinking water wells to enable planning and priority-setting for pesticide regulations across types of pesticides and individual compounds.
- Determine the frequency and range in concentrations, and examine the relationships among pesticide contamination, ground-water vulnerability, and pesticide usage to help focus registrant monitoring requirements (both "where" to monitor and "what" to monitor).
- Enable targeted retrospective field studies by registrants.
- Ascertain whether contamination exists at levels of health concern with sufficient frequency, in association with vulnerability and usage conditions, to move directly, if necessary, to labeling and registration decisions.
- Share Survey results with States to help focus State monitoring and regulatory efforts, and State training and certification programs.
- Determine statistically reliable national estimates of nitrate in ground water for use in implementing the Agricultural Chemicals in Ground Water Strategy.

In November 1984, two key options for the design of the Survey were examined:

- Limiting sampling to areas of high pesticide usage and high vulnerability for ground water contamination; or
- Designing the Survey to characterize the distribution of contamination by randomly sampling areas with different levels of pesticide usage and different geophysical characteristics.

EPA chose to design the Survey to accomplish both objectives within specified cost limits, accepting the need for limitations in the certainty of the Survey's results.

A2.2 Planning Years: 1984-86

From late 1984 through 1985, the Survey was managed by a Steering Committee of representatives from ODW and OPP. By 1985, estimates of the cost of the Survey were put at $5-6 million.

In September, 1985, the Survey design was submitted for peer review to a subpanel of EPA's FIFRA Scientific Advisory Panel (SAP). A subpanel public meeting on the design review was held on October 3, 1985.[3] The Survey design was also reviewed by the National Agricultural Chemicals Association (NACA). The SAP subpanel recommended that the Survey design emphasize private wells, exclude wells not at risk and where explanatory variables are not present, include rural non-farm private wells, and collect considerably more local information to be used in selection of wells. In addition, the SAP subpanel and NACA cautioned that the use of the DRASTIC model might be insufficient (see discussion in the next section) and recommended conducting a pilot survey.

A full-time manager of the Survey was appointed in April 1986. Ongoing coordination continued with other Federal Government agencies, such as the Department of Agriculture, industry associations, health and environmental groups, and State and county officials, including the Association of State Drinking Water Administrators (ASDWA), the State FIFRA Issues Research and Evaluation Group (SFIREG), and the National Association of County Health Officials (NACHO). NPS staff attended meetings on a monthly basis with U.S. Geological Survey staff.

With changes made to incorporate many of the SAP comments into the Survey design, the addition of a pilot study, and an expansion in plans for collecting local information, estimates of the cost of the Survey rose to $9-10 million. In light of these cost projections, the NPS underwent a series of intensive reviews by EPA management with respect to cost containment measures. In September 1986, the Assistant Administrators of the Office of Water and the Office of Pesticides and Toxic Substances made several cost-containment decisions, including the decision to seek voluntary State sampling of community water systems and to eliminate most data collection around community water systems.

In addition, a National Pesticide Survey Regional/State Workgroup was convened prior to implementation of the pilot study and subsequently at key phases of the Survey. The aim of the workgroup was to ensure adequate State and Regional input throughout the process. The workgroup had representatives from several States and four EPA Regional Offices, as well as a representative from SFIREG and key EPA personnel. The group reviewed and evaluated all aspects and phases of the Survey and served as a forum for State input and exchange of information.

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[3] 50 Federal Register 37904, September 18, 1985.

Also during this time period, EPA's Office of Drinking Water was engaged in the development of health advisory levels and documentation for numerous pesticides and other potential drinking water contaminants. The first set of 15 draft health advisories were presented to EPA's Scientific Advisory Panel in June 1986. The panel's critique included the recommendations that the health advisories include multiple calculations of risk, reflect differences among studies upon which the calculations are based, and provide upper and lower confidence limits and maximum likely estimates where appropriate.

Using these recommendations as a guide in revising the process for developing health advisories, in 1987 and 1988 EPA issued 99 health advisories, covering 25 organic chemicals, 7 inorganic chemicals, one microbial agent, and 66 pesticides (including 62 pesticides then of interest to the Survey).

In conjunction with this effort, the Survey staff recognized a need for developing and distributing non-technical summaries of the health advisory documents to the public (and especially to well owners and operators and householders participating in the Survey who would be concerned if pesticides were found in their well water). A draft set of health advisory summaries was reviewed by EPA's Regional Offices, the Conservation Foundation, Concern, Inc., the League of Women Voters Education Fund, NACA, and several focus groups. Commenters stressed the need to clarify the discussion of health effects, the need to explain technical terms sensitively and simply, the need to provide information on practical treatment options for contaminated drinking water, and the need to eliminate risk comparisons when the risks are not comparable on important dimensions (such as the voluntary or involuntary nature of the risk). The health advisory summaries were revised and 59 summaries were issued in January 1989.

A2.3 Pilot Study: 1987

In March 1987, EPA launched a pilot study to field test the major components of the Survey and to provide an opportunity for any necessary revisions or modifications before implementing the full Survey.[4] Between March and August, the pilot study for the NPS was conducted in three States: California, Minnesota, and Mississippi. The States were selected to provide geographic diversity and because of their high level of interest and cooperation. Two of the States, Minnesota and California, had considerable previous experience in State pesticide monitoring programs. Mississippi presented an example of a State with strong interest but little prior experience in this area.

Water sampling was conducted at 48 wells in the pilot study, including both domestic rural wells and community water system wells. Domestic wells were sampled by EPA's contractor, the Research Triangle Institute (RTI), whose staff also conducted interviews with householders regarding the usage and construction of their wells. In addition, data were collected on conditions within the immediate vicinity of the well and within a half mile radius of the well. CWS wells in each pilot State were sampled by State health department officials, after training by RTI. Questionnaires on the construction and characteristics of the wells were also administered to CWS operators.

Because of the concern for data validity, heavy emphasis was placed on quality assurance and quality control procedures in the pilot study. This resulted in an average of 50 bottles of water being taken at each well sampled. The water samples were analyzed in the pilot study by EPA's contractor laboratories (Battelle Columbus and Southwest Research Institute) and by four EPA quality control laboratories.

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[4] For more information on the pilot study, see National Pesticide Survey, Pilot Study Evaluation Summary Report, U.S. EPA, September 1987, or National Pesticide Survey: Pilot Evaluation Technical Report, Contract No. 68-01-7350, Research Triangle Institute, Research Triangle Park, NC. January 29, 1988.

Overall, the pilot study confirmed that major components of the Survey design were in good working order. Specifically:

- Sampling was conducted satisfactorily, both technically and logistically, at selected wells;
- The nine analytic methods were tested. Modifications to Method 3 were accomplished in mid-study;
- The statistical methods developed for the Survey to select domestic wells functioned appropriately;
- Agricultural extension agents were cooperative and informative in providing cropping data;
- Interview questionnaires were straightforward to administer;
- No difficulties were encountered collecting observational data around the wells;
- Survey staff met a high degree of cooperation and interest on the part of householders, with a participation rate of over 90 percent;
- Informed consent procedures were implemented successfully, while maintaining satisfactory participation rates; and
- States were enthusiastic and cooperative, assuming a major role in sampling CWSs.

The pilot study was considered particularly valuable in providing a learning period for trying alternative approaches and for improving procedures and techniques. As a result of the pilot study, recommendations were made for changes in the interview questionnaires, training manuals, and sampling and communications procedures, in anticipation of the full Survey. In addition, the pilot study raised specific issues related to the Survey design, which were analyzed and presented to the Scientific Advisory Panel in September 1987. (See section A3.3 below for a discussion of these issues.)

The SAP gave strong support to the design and approach of the Survey and selected among the options presented on specific design issues. The panel recommended dropping VOCs entirely from the Survey due to problems of obtaining non-aerated water samples, but did not support making any other cost-saving cuts and recommended collecting additional data to enhance the Survey's relational analyses. EPA dropped Analytic Method Number 8, for VOC's, but added three chemicals from Method 8 to Method 7.

In the summer of 1987, protocols for the six new analytic methods developed specifically for the National Pesticide Survey underwent peer review under the auspices of EPA's Environmental Monitoring and Support Laboratory (Cincinnati).

The fall of 1987 saw renewed attention to cost-cutting measures and further management reviews. Measures considered included eliminating one or more analytic methods, sampling fewer wells, eliminating either the domestic or the community well side of the Survey, eliminating well-specific questionnaire and data collection efforts, and extending the project schedule to 1991. It was believed that each of these measures would have seriously compromised the Survey's results or usefulness; none of the measures was selected.

Prior to launching the full Survey, during October and November 1987, NPS staff held a series of meetings with State and Regional staff in every EPA Regional Office around the country. Attendees at the meetings included officials from State departments of agriculture and drinking water supply agencies, EPA Regional Office staff, district representatives of the U.S. Geological Survey, the State Cooperative Extension

Services, and representatives of county organizations. The meetings provided EPA with the opportunity to explain the design of the Survey and its implementation, to review the experience of the pilot study, and to hear and discuss State and Regional concerns and suggestions.

In December 1987, the contract for implementing the full Survey was awarded to ICF Incorporated with Westat Incorporated as a subcontractor. Certain changes were subsequently made in the Survey design, most notably in the use of Random Digit (telephone) Dialing rather than face-to-face interviewing in the third stage selection of the domestic well survey design, a redefinition of the subcounty "cropped and vulnerable" strata in the domestic well portion of the Survey, and changes recommended by the SAP review in light of the pilot study experience. (See Appendix B for a discussion of the statistical design used in the full Survey.) In addition, changes were made in the methods and materials for implementing the Survey. The questionnaires were revised; new training manuals and activities were developed; and sampling, communications, and logistics procedures were refined. (See Appendix C for a discussion of Survey implementation.)

A3 Issues and Decisions

The planning, design, and implementation of the National Pesticide Survey were analyzed thoroughly during the course of the project. This section reviews some of the major issues encountered during the period from 1984 through 1987, grouped under five categories:

1. Purpose and Scope of Survey
2. Early Design Decisions
3. Pilot Study/SAP Issues
4. Communications and Role of States
5. Confidentiality.

A3.1 Purpose and Scope of Survey

At various points in the course of planning the National Pesticide Survey, EPA considered the merits of other related approaches. Early options for the Survey included as objectives the assessment of pesticide contamination of ground water or an assessment of population exposure to pesticides in drinking water. The 1985 SAP review of the Survey design noted that these two objectives were not compatible. The Survey being contemplated could not serve simultaneously as a ground-water study and a human exposure study, although some types of inferences about ground-water vulnerability and the general magnitude of human exposure to pesticides through drinking water were still considered possible with the data that the Survey would generate.

Another alternative considered was to include only domestic wells in the Survey, and exclude community water system wells. The theory was that domestic wells, generally shallower than CWS wells, could function as a sort of early warning indication of a pesticide contamination problem. This alternative was rejected because it would not provide a nationwide assessment of the problem of pesticides in drinking water wells, since community well systems are the major source of drinking water for the majority of the population. Eliminating domestic wells from the Survey, on the other hand, would mean forgoing most of the research and regulatory benefits of the Survey for the Office of Pesticide Programs.

Still another alternative was to focus only on areas where the ground water is especially susceptible to pesticide contamination or on areas where pesticide usage is known to be high. This so-called "hot spots" approach was rejected, however, because it could not provide results that could be generalized to all wells. In other words, there would still be no national estimates for the country as a whole. Moreover, there was insufficient information to help pick the wells to investigate. Similar reasons led to rejection of both a "case studies" approach that would investigate only a few areas in great detail and the option of conducting statistical surveys in only a few States.

Other measures limiting the scope of the Survey were examined for purposes of containing costs. These included:

- Reducing the number of analytes and analytic methods;
- Changing the precision requirements for the results and/or sampling fewer wells;
- Changing the requirements for confirmation of positive detections;
- Using fewer strata in the design of the Survey (e.g., collapsing the four usage and three ground-water vulnerability strata to a two-by-two matrix);
- Selecting CWSs as planned but then surveying private wells only in the vicinity of the selected CWSs;
- Eliminating questionnaire interviews and the collection of observational data entirely, or eliminating them for CWS wells;
- Relying only on first stage stratification to select wells randomly both for domestic and CWS wells; and
- Eliminating random sampling at the third stage and instead selecting wells on a quota basis within clusters.

Most of these approaches would have narrowed the focus and usefulness of the Survey's results, in some cases drastically reducing the credibility of the results for use in regulatory programs, in other cases running counter to repeated SAP recommendations specifically supporting the need for the data in question.

A3.2 Early Design Decisions[5]

Agricultural Pesticide Use

Originally, all types of pesticide usage were to be included in the Survey: agricultural, home and garden, industrial, rights-of-way, commercial, and government. However, because no detailed information existed even on the national level in 1984 for the last four categories, the decision was made to focus the first stage data collection effort on agricultural pesticide use. The pesticide usage information task group formed in 1984 examined 12 options for developing county-level agricultural use data for the pesticides of greatest concern.

Two promising resources were the Census of Agriculture for crop acreage and Doane Marketing Research, Inc. for regional pesticide usage for 28 major and minor crops. A small study of five pesticides used on four crops in Wisconsin was conducted using Census of Agriculture data to determine if county-level estimates of the agricultural use of specific pesticides were possible. The Doane data were also compared to a database compiled by Resources for the Future, which was viewed on balance as no better suited to the purposes of the Survey.

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[5] For more information on this section, see National Survey of Pesticides in Drinking Water Wells: A Review of the Planning Process and The Data Quality Objectives, by Monica Nees and Cynthia Salmons, Contract No. 68-01-7350, Research Triangle Institute, Research Triangle Park, NC, July 6, 1987.

The 1985 SAP reviewers approved the use of the Doane Marketing Research data for the first stage of the Survey but stressed the need to supplement the information with "as much local information as possible on the historical pattern of pesticide use in the immediate location of the well, the climatological, soil and hydrogeological conditions, and the characteristics of the wells themselves."[4] The subpanel steered EPA towards obtaining local information from pesticide registrants and local pesticide distribution centers, State departments of agriculture, and local offices of USGS, SCS and the cooperative extension service.

Subsequent debates centered on the type of localized crop and pesticide usage data that should or could be collected in the field in the second or third stages of the Survey. By January 1987, consensus had emerged that some information on either crops or pesticide usage was necessary for the relational analyses to be performed, that there was a need for consistency in the resources and effort devoted to the different data elements in the Survey, and that the pilot study would be useful in testing different data collection methods.

A number of options were considered at the time (some were tested in the pilot study), including:

- Conducting a "drive-around" or "walk-around" informal look at cropping activity within a mile or half-mile radius of each domestic well;
- Using a farm questionnaire to collect more detailed information for the estimated 100-125 domestic wells that would be located on farms (this was dropped because it would yield good information for too small a sample);
- Using more sophisticated methods (e.g., a combination of satellite data and fly-overs) to obtain detailed crop information for a specified radius around each domestic well (this was dropped for reasons of cost); and
- Using data from the National Agricultural Statistical Service (NASS). (NASS's area sampling units were investigated as possible alternatives to the use of Census Bureau enumeration districts and block groups as the basic sampling units of the Survey. The NASS sampling units also carry agriculturally related land-use information that would have been useful for the second stage stratification. However, it was determined that the NASS sampling units would not have been compatible with the Survey design, which at the time relied on enumeration districts and block groups.)

Ground-Water Vulnerability

The use of DRASTIC to characterize vulnerability of ground water was discussed extensively in early stages of the Survey design. The National Water Well Association was asked to review EPA's use of DRASTIC. They gave a positive review but cautioned that DRASTIC had not been designed to yield a single numeric vulnerability score for an entire county and that this problem would be magnified in larger counties that contained varied hydrogeological features.

The 1985 SAP subpanel urged EPA to use local deterministic data to supplement DRASTIC. In their view, DRASTIC was capable only of a rough categorization of counties, it pertained only to shallow water vulnerability, and some of its parameters overlapped or were not strictly related to actual vulnerability. The SAP subpanel questioned why EPA did not use its own PRZM (Pesticide Root Zone Model) model which

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[4] The results of the SAP Subpanel were reported on October 9, 1985: Federal Insecticide, Fungicide, and Rodenticide Act Scientific Advisory Panel Subpanel Review; Technical Review of the Preliminary Design of the National Survey of Pesticides in Ground Water – Report of SAP Subpanel Recommendations, p. 4.

"emphasizes climate and the upper layers of soil that are the primary determinants of pesticide persistence and mobility."[7]

However, PRZM was considered by Survey designers to be a site-specific model that would have required extensive modification to be applicable to county-scale parameters and to include relevant characteristics that influence ground-water vulnerability. Other site-specific approaches were also available; in general, however, there were very few large area approaches available and none with the consensus of DRASTIC. Moreover, DRASTIC was being proposed for use as an average, relative ranking index, not as a quantitative predictor. Its utility was primarily as an aid to stratification rather than as an explanatory variable in its own right. Finally, to validate DRASTIC scoring, 220 counties were rescored independently by one or two hydrogeologists. The results demonstrated that any variability in DRASTIC scoring was not large enough to obscure actual differences in county-wide vulnerability categories and that the stratification needs for the first stage of the Survey could be achieved with DRASTIC.[8]

The SAP reviewers also noted that the lack of well construction information and knowledge of well casing integrity (particularly for domestic wells) could introduce even more uncertainty into the Survey's results than DRASTIC. As part of the pilot study, EPA undertook a well depth validation study to determine the significance of this source of uncertainty and concluded, as described in Section A3.3 of this appendix, that reliable information on well depth was desirable but difficult to obtain.

Precision Requirements

During the summer of 1986, a number of options for defining the precision requirements of the Survey were analyzed in detail. The options examined the size of the sample required to produce results of a given power or relative standard error under varying assumptions about the "true" rate of contamination of drinking water wells (e.g., 0.5 percent, 1 percent, 2 percent, and 5 percent). If reasonable estimates had been available of the proportion of contaminated wells or systems, an efficient allocation of samples across strata would have been possible. Since they were not available, the samples were allocated to ensure that frequencies of occurrence as low as 0.5 percent could be detected at the national level.

Thus, the CWS sampling scheme devised was intended to provide a 90 percent probability of detecting the presence of pesticides in the sample if 0.5 percent of all community water systems in the country contained pesticides. This is fairly conservative; the precision of the results would of course be much better if more than 0.5 percent of all CWSs in fact contained pesticides.

The domestic well statistical design was intended to yield a range of probabilities of detecting pesticides in different domains. The strategy was to employ a sampling design to obtain the highest power (higher power being defined as higher probability of detecting occurrence) in the vulnerable/high use counties and in the cropped and vulnerable subcounty areas of those counties, and to accept a slightly lower power in the national level estimates. Areas of particular concern for pesticide detection were oversampled in order to yield better, more precise estimates. Thus, the likelihood of the Survey detecting pesticides in domestic wells was 63 percent at the national level (assuming a 1 percent rate nationally), but the Survey had a 97 percent chance of detecting pesticides in cropped and vulnerable areas (assuming a 0.25 percent actual rate of pesticide presence in wells in these areas).

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[7] October 9, 1985, Report of SAP Subpanel Recommendations, p. 5.

[8] Alexander, W.J. et al. Ground-Water Vulnerability Assessment in Support of the First Stage of the National Pesticide Survey. EPA Contract No. 68-01-6646, Research Triangle Institute, Research Triangle Park, NC, 1986.

Analytical Methods Development

Among the issues in preparing for the Survey was the question of the reporting limits that could be achieved, whether they were sufficiently low and whether lowering them still further could be done at a reasonable cost. Issues of data quality, cost, and comprehensiveness were closely interrelated. The sensitivity of the analytic methods declined slightly as the number of chemicals analyzed per method increased. In addition, ODW and OPP had somewhat different concerns in the reporting limits issue. ODW was primarily interested in determining whether pesticides existed at levels of health concern. OPP was also interested in characterizing the nature and extent of pesticide presence in well water, and hence favored low analytical limits. Conceptually, it was agreed that in setting reporting limits, EPA should strive for levels that are commensurate with the levels found by States in other surveys and that the public is familiar with; that a reporting level should be well below the health advisory level for the pesticide; and that reporting levels should be capable of giving an adequate picture of the extent of pesticide presence in wells.

A3.3 Pilot Study/SAP Issues

Four major issues raised by the pilot study were presented to a subpanel of EPA's Scientific Advisory Panel in September 1987.[9] The first was the ability of the Survey to meet the objectives specified by EPA, particularly with respect to the Survey data analyses. Additional issues for consideration included the well selection method for community water systems, temporal variation, and the instability of certain analytes.

Meeting Survey Objectives

Number of Wells Sampled. A key objective of the NPS was to conduct "relational analyses" comparing the results of the well sampling with cropping or pesticide use patterns and hydrogeological data. There was concern that the anticipated sample size of approximately 750 domestic wells would be minimal for conducting the relational analyses, especially for pesticides with highly limited or specialized geographical uses. A sample size of 1,500-2,000 domestic wells would be preferable for the relational analyses.

Options considered to remedy the situation included adding more wells in the domestic well component of the Survey (infeasible due to high costs per well) and collecting "second stage" cropping and hydrogeological data for the community water system wells (which would not necessarily be as helpful as the same data for the domestic wells). The SAP responded that the number of wells sampled could not be increased by a significant enough number to affect the confidence of the interpretations. Based on this response, EPA maintained the sample size.

Well Depth Data. The "well depth validation study" conducted during the pilot study identified and examined well construction records available from householders, State and municipal archives, well drillers, and the WATSTORE data base maintained by USGS. The purpose of the study was to determine whether interviewees had sufficiently accurate knowledge or recall of well information; the extent to which records with information on well depth and construction were available to corroborate or supplement householders' recall; the location of these records; and the costs of locating them.

The conclusion of the study was that it would be extremely difficult to find reliable, direct information on well depth for all sample wells. However, the States tended to have information on well construction in the areas of the sample wells that could be used to infer well depth and the type of aquifer tapped for many of the sample wells. The SAP recommended continuing with the same "search" procedures in the full Survey, contacting State officials and well-drillers, and when necessary, using inferential data from neighboring wells. During second stage data collection for domestic wells, EPA implemented the panel's recommendations. For CWSs, EPA determined that system operators would, in general, have better information on well depth than other sources.

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[9] 52 Federal Register 33991, September 9, 1987. The results of the SAP Subpanel review were reported on October 9, 1987: Federal Insecticide, Fungicide, and Rodenticide Act Scientific Advisory Panel Subpanel; A Set of Scientific Issues Being Considered by the Agency in Connection With the National Pesticide Survey Pilot Study – Report of SAP Subpanel Recommendations.

Second Stage Data. The Survey design called for collecting second stage data to help direct the stratification of the sample. The second stage cropping data and DRASTIC scores were consistently available; however, the second stage data were expensive to develop, and they covered large subcounty areas (e.g., hydrogeologic settings), which might not accurately reflect conditions around the sample well. Conversely, data on well characteristics collected through Survey questionnaires and records searches were more accurately targeted to the sample wells than the second stage information; however, there was concern that the data simply might not be available for a large number of wells.

In an effort to be sure that the gains achieved by the second stage stratification were worth the expense of the second stage data collection effort, EPA came up with a number of alternatives to the original plans for using DRASTIC:

- **Use of type settings** developed by the National Water Well Association to direct the second stage stratification. This approach would reduce the hydrogeologic data gathering effort, although at the cost of some accuracy.
- **A simplified DRASTIC scoring** could be undertaken, using a smaller set of hydrogeological characteristics (such as topsoil, slope, and depth to water) to categorize high, moderate, and low vulnerability areas within each county. Again, this approach would reduce the hydrogeologic data gathering effort, reducing accuracy as well.
- **Use of a geographic information system** (GIS) to save time and money in averaging the DRASTIC scores and transferring them to subcounty areas. The overall cost savings to the project of using this approach were not clear.

The SAP recommended the following:

- Continued stratification at the second stage but using a simpler approach than DRASTIC scoring (e.g., type settings) and a refinement in collection of cropping data at the second stage.
- Refining and augmenting well-specific information collection, by asking well owners more information, expanding the local area data collection effort, and asking for State help in searching for well depth data.
- If enough positives appeared after three months, pursuing added well-specific data collection: DRASTIC scoring of half-mile radius around well; Survey of agricultural chemical dealers; farm property Survey.

After careful consideration of the alternatives and SAP's recommendations, EPA decided to use a simplified version of DRASTIC and a GIS program to conserve time and money. In addition, EPA expanded the data collection effort at the second stage to include more information on crops and pesticide use. As part of this data expansion, questions on well-specific characteristics and farming practices were added to the questionnaires.

Well Selection for Community Water Systems

The study design called for community water systems to be selected for the Survey from the Federal Data Reporting System (FRDS) data base. The pilot study uncovered numerous problems with FRDS, necessitating changes in the statistical design for the community water system component of the Survey.

The most serious problem encountered was with the FRDS data on number of wells per system. According to the FRDS data base for 1984-85, 83 percent of CWSs had one single well; 7 percent had two wells; and only 10 percent had three or more wells. Based on that information, the Survey was designed to estimate the number of community systems in the country with at least one well containing pesticides. The implication was that virtually every well in every selected system would be sampled and analyzed.

In the course of screening the systems for the pilot study, however, it was found that the selected CWSs had many more wells than were shown on FRDS -- on average 5.75 wells per FRDS record rather than the expected 1.5 wells per system. Although one could not generalize from the pilot study systems, any number substantially higher than 1.5 wells per system would have made sampling each well in each selected system, as originally planned, extremely costly. (It would also have focused CWS sampling on fewer systems, thereby limiting observations to fewer geographic areas of the country and reducing the precision requirements of the Survey.)

To solve this problem, EPA proposed to develop a list of CWS wells (rather than systems), from which a sample of CWS wells could be selected, using a three step design. In step one, a sample of systems would be selected with equal probability from FRDS without replacement from within strata. The sample would be screened by telephone to determine the number of wells operated by each sample system. This information would be used at step two to select a subsample with probability proportional to size (number of wells). At the final step three, a single well would be selected from each of the systems in the subsample.

The SAP found this approach generally acceptable and suggested additional options: cleaning the FRDS data base prior to using it (considered too costly); continued oversampling at stage one; exploring the "false negatives" problem (considered too costly); exploring the use of counting rules to deal with multiplicities; and oversampling higher risk wells as well as systems. EPA followed the recommendation of the panel and implemented the three step approach.

Temporal Variation

A statistical design issue affecting the appropriate interpretation of the Survey results for both the community water system and the domestic well components of the Survey is the temporal or seasonal variation of pesticide detection. The Survey was expected to be conducted over a two year period, but it was not originally designed to provide a random sample over time, and the Survey design did not "control for" seasonality. Because of laboratory capacity constraints, it did not appear feasible to eliminate all effects of seasonality by condensing all the sampling into a small time period (i.e., three months).

Among the options considered by EPA were: (a) to develop a reasonable-cost method of distributing the sampling for any given region of the country over the course of a year in order to incorporate temporal variation into the sampling schedule; (b) to consider temporal variation in the Survey data analyses, but not in the sampling schedule; and (c) not to pursue this issue further because of scientific uncertainties and the nature of the Survey design.

The SAP advised randomizing the sampling over time using practical approaches, or, if randomizing at the well level proved too costly, to randomize at the county, system, or State level. The SAP also advised EPA not to overinterpret the results of the NPS in terms of temporal variation because the Survey data base was not designed to incorporate the wide variability in the factors that influence temporal changes. Based on the panel's recommendations, EPA decided to randomize sampling of community wells at the well level and domestic wells at the county level.

Analyte Instability

Limited time storage studies showed that some pesticide analytes appeared to be unstable during the period between collection and analysis of the sample. EPA asked the SAP's opinion on the following questions:

- If there is a stability problem, is it appropriate to address the issue in the context of the Survey? Or should the issue be addressed more appropriately as a separate research project?
- If there is a stability problem, should unstable analytes be deleted from the Survey analyte list? What criteria should be used to make such decisions? Would it be advisable to delete the "problem analytes" from the list of Survey analytes, but have the laboratories continue to test for them and report them if they are found and confirmed?
- How should EPA report results to domestic well owners and community water system operators, if the Agency suspects that certain analytes are unstable?

The SAP responded that this issue should be addressed in the context of the Survey, beginning with a review of literature and EPA data bases and proceeding to time storage studies. The panel further advised not deleting any analytes until the nature of the instability was better understood. If a real instability problem was found that could not be adjusted for, the panel advised not to analyze or report data for those analytes.

A3.4 Communications and Role of States

Communications represent an integral part of any large-scale effort dealing with the public. The National Pesticide Survey involved the cooperation of all 50 States, the active involvement of all ten EPA Regional Offices, the services of eight different laboratories, the assistance of the U.S. Department of Agriculture and the U.S. Geological Survey, and the good will of numerous individuals across the country.

A great deal of attention was therefore given to establishing communications mechanisms throughout the course of the Survey, with four primary goals: (1) establishing and maintaining a mechanism of ongoing information exchange; (2) ensuring the identification and involvement of all potential project participants and interested parties; (3) ensuring adequate project information dissemination; and (4) ensuring adequate collection of project-related information and the consistency and quality of the Survey results.

Role of the States. State agencies played a key role in implementing the Survey. State drinking water supply agencies were asked to sample the selected community wells and to notify both domestic well owners and community water system operators of the results of the NPS sampling. Both State drinking water supply agencies and departments of agriculture were asked to serve as points of contact for communications with interested parties and to provide follow-up and technical assistance.

This important role of the States was decided upon for several reasons. First, State agreement to take samples would greatly reduce the costs (particularly transportation costs) to EPA of sending out sampling teams across the country. (Otherwise, since the CWSs were to be sampled on a randomly-based schedule, samplers would have to return to the same State a number of times, raising the costs of the Survey.) A second and important reason was the existing working relationship between community water system and State drinking water supply agencies. It was anticipated that having State agency staff act as the samplers would result in better cooperation on the part of the CWSs and therefore provide more assurance that the samples would be taken. State officials were also concerned about possible interference with their existing relationships with CWS personnel.

Several disadvantages to this extensive State role were raised in planning the Survey. First, there was the potential for inconsistency in sampling practices across States. Even if State officials were experienced samplers, their methods would likely vary widely across States. To address this issue, EPA's contractors carried out 54 intensive training courses in 45 States for EPA and State samplers. Second, there was the fear that for reasons of insufficient resources or too many demands on their schedule, States would not be able to meet the NPS schedule, thereby throwing off the efforts to spread sampling across the year as much as possible. This was largely overcome through careful attention to communications (in terms of going over the schedule with the States in advance and then monitoring the sampling dates) and by offering States a two-week period in which to conduct the sampling.

States also played a prominent role in notifying well owners, operators, and householders of the results of the well sampling. Householders and CWS owner/operators were likely to contact the State anyway when they obtained their results, as were media and community officials. It was therefore decided that everyone would be best served if the States were provided with the Survey results as soon as they became available, on an ongoing, routine basis. State personnel also coordinated participation by county officials, who also played a large role in responding to public inquiries about the Survey and in providing information about hydrogeologic characteristics and agricultural practices. (The issue of confidentiality as related to the States' involvement in notification is discussed in the section below.)

Numerous other communications issues were addressed during the course of planning the Survey, particularly with regard to notification procedures. For example:

- **Notification by Mail or Telephone.** Both mail and telephone have advantages and disadvantages as a means of communication -- telephone calls can be unnecessarily alarming or intrusive but may communicate better; letters may not be read or understood but are more permanent records of the sampling results. It was decided that in the event of a positive finding above health advisory levels, the Survey Director would call the State and Region to alert them the same day as the laboratory reported the confirmed results to EPA. This was known as the Rapid Reporting System. The States would then be asked to call well owners and operators to inform them of the results, followed up with a notification letter. Within three days of receiving written confirmation of the results by the laboratory, EPA would notify the State in writing of the findings. State contacts in the Departments of Health were encouraged to send notification letters and supplementary information to well owners and operators within one week of receipt of the results and to make follow-up calls if necessary.

- **Notifying Well Owners vs. Householders.** Both for health reasons and potential legal concerns, it was determined that both well owners and the tenants (where applicable) needed to give permission for sampling and to be notified individually of the sampling results.

- **Media Attention.** Attention was given to notifying the proper State and local officials in each State prior to sampling in order to ensure that each level of government was aware of EPA's presence before the Survey was reported in the media. Another concern, raised by the Office of Management and Budget during its review of EPA's information collection plans, related to the pilot study results. There was concern that EPA not publicize the pilot study results, because they would not be representative of the national situation and could easily be misinterpreted by the media or the public. (For this reason, the pilot study results were not included in the pilot study evaluation reports.)

- **Resampling.** Concerns were raised in planning the Survey about the need for, cost, and implications of resampling wells that were found to contain pesticide residues. Issues of protocols and responsibilities for resampling were raised by the SAP as far back as 1985 -- for example, when should resampling be done and by whom, how should the results of resampling be presented to well owners particularly in light of seasonal variations, confidentiality concerns; and whether positive findings should be reported in the absence of resampling. Several States raised concerns about taking any type of action with respect to a drinking water supply based solely on one sample. It was agreed that States would conduct the resampling in the event of a positive finding and that EPA's laboratories would conduct the sample analyses. Because of the possibility that the results of the resampling would bias results, however, the resamples were not included in the Survey analysis.

A3.5 Confidentiality

EPA's policy on the release of well sampling results of the National Pesticide Survey favored full disclosure of information. However, issues of confidentiality of the results were raised early in the design of the Survey and discussed extensively. The key issue was the degree to which EPA should protect participants' privacy and encourage them to participate in the Survey.

A general policy on confidentiality was also needed to guide the handling of requests for information under the Freedom of Information Act (FOIA), although each FOIA request must be considered on a case-by-case basis. Under FOIA, EPA is required to release information unless EPA determines that one of nine FOIA exemptions applies to the information. EPA cannot, for example, temporarily delay release of information to allow a State time to respond to the situation. EPA also cannot delay release of information until the end of the Survey when the results are considered "final." The exemption that was most clearly applicable to NPS data is Exemption 6, which protects personal privacy.

The concern about confidentiality related only to domestic wells (none of the CWS data could be considered to raise a personal privacy issue). The focus of the concern related to the names and addresses of the Survey participants, as well as the Domestic Well Questionnaire data they provided and the results of the sampling (to the extent these data could be identified with the specific participants).

The competing issues involved included the following:

- **Maintaining the States as Partners in the Survey.** The partnership approach of the National Pesticide Survey with the States was unique among Agency surveys. It helped develop constructive working relationships between EPA and the States and fostered closer relations among ground water, drinking water, and pesticide agencies. It also comported with the States' general responsibilities for the water supplies of their residents. Many States made it clear, however, that they would participate as partners only if they received full information from EPA on the Survey, including the results of the domestic and community well sampling, linked to the names and addresses of Survey participants.

  Some States, however, also indicated that they could not keep the sampling results and participant identities confidential. California, for example, is required by law to make all such information available to the appropriate local health departments, who have varying policies about releasing the information to the public. Other States were not constrained by law, but by policy, or by data management systems that were not geared towards protection of personal information.

The variations among States in confidentiality policies created several difficulties. First, to the extent that information was in the public domain (or potentially so) in States that could not or would not maintain confidentiality, the Agency's case for withholding the information under FOIA request was greatly weakened. EPA would likely not be able to withhold in the States in question and might not even be able to withhold in all States under FOIA.

A second issue was what EPA should tell participants about confidentiality, given that State policies varied. If EPA could not make a strong assurance of confidentiality, it was not clear whether EPA should give participants a written statement on confidentiality, or instead, not raise the issue at all but instruct contractor personnel on how to answer any questions that might arise.

- **Protecting the Privacy of Survey Participants.** Some of the information asked on the questionnaire could conceivably be considered sensitive or embarrassing or more generally, the kind of information that people customarily maintain in confidence. EPA was also concerned that participants be protected from intrusion and potential harassment by commercial vendors and the media. It was thought that potential NPS participants might require confidentiality out of fear that public disclosure of adverse information about their property would lower their property values and make their homes more difficult to sell. Also, it was thought some participants might be concerned about their personal liability for contaminated water supplies -- they might worry that their neighbors would find out about pesticide detection and sue them or that the State would take action against them.

- **Ensuring the Statistical Integrity of the Survey.** Assurances of confidentiality are generally believed necessary to convince people to participate in a survey. Because of the concern that people with a higher likelihood of having well water containing pesticides would disproportionately refuse to participate in the Survey without a promise of confidentiality, there was also concern that this could affect the statistical integrity of the Survey. Failure to obtain an accurate national picture of the presence of pesticides would then run counter to the larger interests of the public. Empirically, the results of the pilot study seemed to indicate that confidentiality would not be a major concern on the part of individual householders and that they would not mind sharing the analytic results with the States.

  NPS staff also reviewed the experience of other EPA Surveys. The Radon Survey conducted by the Office of Radiation Programs planned to release data only to homeowners, with none of the data to be released to the State; individual household results were expected to be withheld under FOIA. The Asbestos in Schools Survey conducted by EPA's Office of Toxic Substances inspected for asbestos in school buildings and kept all the information confidential. Results were not even reported to the school boards themselves. After the data base was complete and "clean," the Survey destroyed the names and locations of the schools.

- **Protecting the Public Health.** From a public health perspective, it was anticipated that communities where NPS sampling was taking place might have a strong interest in the sampling results. For example, if only one aquifer was used for drinking water in the area near an NPS well, and the sampling results gave reason to suspect wider contamination, the health of the residents of the surrounding area might be at risk as well. This would argue in favor of a more open NPS disclosure policy.

  On the other hand, it was not clear that the public interest extended beyond the sampling results obtained in the community, to the names and addresses of the Survey participants. To strengthen the public health protection of the communities involved with the Survey, EPA could, for example, explicitly recommend to the States that they inform communities of suspected problems with particular aquifers or particular types of wells but without releasing the participant identities.

EPA considered a variety of options in an effort to meet these competing interests and goals. They included the following:

1. That EPA defer to State law and policy in each State, in order to be consistent with the State's standard procedures. However, this policy would not have been legally supportable under FOIA. EPA is not permitted to withhold information merely because State law protects the information.

2. That each well owner be allowed to decide whether or not to have the State receive the sampling results. This policy would have been a logistical nightmare for data management and notification; it would also have severely limited the State role in the NPS and required EPA to offer follow-up assistance.

3. That all information (identities, sampling results, and questionnaire data) be maintained by the contractors at their offices rather than at EPA, because from an operational point of view, there is no necessity for EPA to maintain these records. Under this approach, the records would not be subject to FOIA. This option was rejected as impractical for all except the questionnaire data, given the desired involvement of the States and Regional Offices in the Survey notification process.

4. That although EPA would not publicize participants' identities on its own initiative, the Agency would determine in advance that participant identities are generally not withholdable under Exemption 6 and consequently that EPA would generally make the information available upon request unless there was reason to believe that the disclosure could be harmful to the participants.

5. That EPA would seek to withhold participant identities except in response to written FOIA requests where the Agency found that the public interest in disclosure of the data was relatively stronger than the privacy interest.

6. That EPA would share the sampling results only with States that could withhold personal information. States that could not or did not intend to protect personal information would not receive the participant identities, and would receive the sampling results only in coded form. In those States, EPA would notify participants of their results.

The option selected (#5) was incorporated into the confidentiality policy adopted for the National Pesticide Survey (shown in Exhibit A-2). Appendix C describes the operation of the confidentiality policy and reporting system during implementation of the full Survey.

Exhibit A-2
NPS Confidentiality Policy

EPA's policy on the release of well sampling results of the National Pesticide Survey favors full disclosure of information. Results from the sampling of community water system wells will be made public as soon as the State and CWS have been notified.

However, where the sampling results relate to the wells of private individuals, the policy will be modified to protect individual privacy, while still permitting disclosure of sampling results. EPA will also seek to obtain agreement from the States to protect the confidence of personal information on Survey participants.

Efforts to maintain confidentiality include the following:

- Owners of private wells will be asked to read and sign the Water Sample Consent and Data Release Agreement Form which acknowledges that their well sample results and questionnaire data will be shared with the State. Spot checks of these forms will be conducted to ensure that they are being completed.

- Each State may be asked to provide a written statement of its ability to maintain confidentiality. In those States where reasonable assurances cannot be given, a revised release form may be used, giving the well owner the option of having the sampling results go no further than EPA and the contractor.

- EPA will ensure that Survey records are not accessible by the name or address of any individual. Files will be organized instead by an anonymous internal code to be assigned to each well in the Survey (e.g., "Well #23, Well #37"). The "cross-reference" file linking the internal well code with the name and address of the well owner will be accessible only through the well code. Access to the cross-reference file will be restricted to those with specific project responsibilities.

- The contract laboratories will be legally bound to observe confidentiality procedures. The contract laboratories will not have access to the names and addresses of the well owners; samples will be linked to the well from which they originated by the internal project code number only. Spot checks of data management procedures will be conducted during the regular audits of the laboratories.

- Results of domestic well sampling and other information will be released in reports prepared for EPA only in appropriately aggregated form (e.g., "X percent of all wells...") or by anonymous well code. Personal information (i.e., names and addresses and other identifying details) will not be included in EPA reports.

National Pesticide Survey

Appendix B: Statistical Design and Analysis

Appendix B: Statistical Design and Analysis

B1 Introduction

This appendix describes the key elements of the statistical design and analysis for the National Pesticide Survey. With respect to the statistical design, this appendix presents the following information:

- the final precision requirements that the designers of the Survey established as the basic level of confidence for the results of the Survey;
- the mathematical procedures that were used initially to determine the numbers of community water system wells and rural domestic wells that would constitute the sample of wells;
- changes in statistical design based on the results of the pilot study and other reviews of the initial Survey planning;
- the final procedures used to screen wells and identify those wells from which data would be obtained during the field sampling phase of the NPS; and
- the actual response rates for the Survey (i.e., the numbers of wells from which the Survey obtained data).

In addition to describing the design of the Survey, this appendix also explains the key statistical concepts and implementation procedures that were used to produce the results presented in Chapter 6 of the Phase I Report. In particular, this appendix discusses the following analytic topics:

- scheduling of well sampling, and the analysis of whether temporal variation affected Survey results;
- procedures used to handle missing data and questionable data, including imputation procedures;
- weighting procedures through which the wells actually sampled represent wells in the population;
- procedures for calculating national population estimates based on well sampling results, weighting, and other statistical procedures; and
- a comparison of the results presented in Chapter 6 with the initial precision requirements of the Survey.

As the first national survey of drinking water wells, the NPS involved a number of design assumptions and innovations. In addition, at certain points the design was partially revised to reflect changes in goals or procedures. The purpose of this appendix is to describe and state the design assumptions, identify the data sources used in the Survey design, explain statistical concepts and procedures and provide the most important mathematical equations underlying the Survey design and analysis.

Section B1 provides an overview of the Survey design goals and the basic sample design for the CWS and rural domestic well surveys. Section B2 describes the first stage stratification that is common to both the CWS and rural domestic well surveys. Section B3 provides further details of the sample design for the CWS well survey and Section B4 similarly provides further detail of the sample design for the rural domestic well survey. Section B5 discusses the temporal allocation of sampled wells in both surveys. Section B6 provides details of the statistical procedures required to produce the results presented in Chapter 6 of this report and discusses the actual precision achieved by the survey in comparison to the precision requirements specified for the design.

B1.1 Key Elements of the Survey Design

The Survey was designed to collect samples from drinking water wells across the country. The Survey also collected information about well construction, physical surroundings, and land use for investigation of possible relationships among analyte detections and ground-water vulnerability and pesticide use. The Survey was not designed to assess ground water or drinking water. Well water samples were collected before treatment.

Originally, the Survey was designed to provide estimates of characteristics of community water systems, and rural domestic wells. Before determining the number of community water systems, and rural domestic wells to include in the Survey, the respective populations needed to be defined, and the population sizes estimated.

Community water systems are defined under the Safe Drinking Water Act and its regulations as systems providing piped drinking water with at least 15 connections, or serving a population of at least 25 persons who are permanent residents of the service area. For the purposes of the Survey, a CWS was further defined as a system with at least one working well that is used to obtain drinking water. The estimate of the number of community water systems was based on the Federal Reporting Data System (FRDS) listing for the period from July 1984 through June 1985. FRDS is a database that is maintained by the EPA Office of Drinking Water that contains information on public water supply systems. The number of community water systems was initially estimated to be 50,771.

Rural domestic wells were defined for the Survey as drinking water wells that supply occupied housing units located in rural areas of the United States, except for wells located on government reservations. The United States Bureau of the Census (Census Bureau) defines rural areas as areas outside of incorporated or unincorporated places with a population of 2,500 or more, or as areas outside urban fringe areas (for more information on the definition of urban and rural areas see Appendix C). The number of private rural domestic wells was initially estimated as 13,102,000 based on the 1980 Census.

The Survey uses a stratified sampling design. In general, stratified designs are used to improve the precision of parameter estimates by controlling the distribution of the sample. First-stage stratification was common to both CWS and rural domestic well surveys. Each of the 3,137 counties or county equivalents in the United States was categorized by pesticide use and ground-water vulnerability. This ensured that samples were taken from wells located in areas with different levels of pesticide use and ground-water vulnerability, and provided a mechanism for oversampling wells in areas that had greater *a priori* expected detection rates. The first stage stratification was the same for both the community water systems and rural domestic wells, and is explained in section B2. Further details of the sampling designs for CWS and rural domestic wells are provided in Sections B3 and B4 respectively.

The Survey design also identified particular subgroups of the populations of drinking water wells that were of special interest. These subgroups, termed "domains of interest," constituted categories of wells about which it was particularly important to obtain information. These domains were based on the various strata introduced into the Survey design. The seven domains of interest were:

- All CWS wells in the United States;
- CWS wells in counties with high ground-water vulnerability;
- All rural domestic wells in the United States;
- Rural domestic wells in counties with high pesticide use;
- Rural domestic wells in counties with high ground-water vulnerability;
- Rural domestic wells in "cropped and vulnerable" county subregions; and
- Rural domestic wells in counties with high pesticide use and high ground-water vulnerability.

Once the populations had been established, the number of samples necessary to provide specified levels of precision were calculated. A detection rate was assumed for each of the seven domains, and the precision requirements (in terms of variances, relative standard errors, detection probabilities, and confidence intervals) and estimated costs for each stage were specified (the costs were specified in terms of dollars per well). The sample allocation was calculated to achieve the required precision for the least overall cost. The mathematical procedure used to perform this constrained optimization problem is based on Kuhn-Tucker theory. The mathematical procedure for the CWS and rural domestic well Surveys is explained in Sections B3 and B4 respectively.[1]

The Survey was designed to estimate detection rates for the presence of any of the pesticides or pesticide degradates (101 pesticides and 25 pesticide degradates). The precision requirements for the Survey were specified for the expected detection of at least one of these pesticides or pesticide degradates, rather than for the detection of individual analytes. Survey results for the presence of at least one pesticide are in accordance with the pre-specified precision requirements. The Survey was not designed to provide estimates for individual pesticides or pesticide degradates, and in general, a much larger sample would be needed to achieve the specified precision for individual pesticides given the assumed detection rates. Furthermore, if the Survey had been designed to determine the presence of any one pesticide then a different stratification would have been used (for instance, highlighting use areas for that pesticide specifically). For these reasons, results presented in Chapter 6 for individual analytes generally contain larger relative standard errors than results presented for all pesticides together. If actual detection rates in the Survey are different from the assumed rates used for the survey design, then the precision of survey estimates will be different than original precision specifications.

B1.2 Pilot Study and Initial Design Review

EPA conducted a pilot study from March to August, 1987, to test the major components of the Survey and to provide an opportunity for any necessary revisions or modifications before the full Survey was implemented.[2] The pilot study was conducted in three States: California, Minnesota, and Mississippi. The pilot study led to improved procedures and techniques in several areas. In October, 1987, the FIFRA Scientific Advisory Panel (SAP) subpanel commented on several topics, including the proposed method of selecting CWS wells for water sampling, and the issue of temporal variation (seasonal patterns of pesticide application, precipitation, and other similar phenomena) as a factor influencing when, and in what concentration, pesticides and nitrate impact drinking water wells.

In response to the SAP subpanel's recommendations on methods of selecting CWS wells, the CWS survey design was altered from a survey of community water systems to a survey of CWS wells. Further details are given in Section B3.

The NPS pilot survey is described in Appendix A. There were three parts of the pilot survey that directly influenced modifications made in the statistical design of the full Survey: adequacy of the CWS frame, use of an area probability design for sampling within first-stage units, and selection of wells to be sampled within some of the counties.

The frame for the CWS survey was the 1984 Federal Reporting Data System (FRDS) file. This multi-purpose data base includes all community water systems reported to the Federal Government by State agencies. At the time of the pilot survey it was believed that the variable "number of water sources" indicated the number of wells used by those systems that stated they used ground water. Since this number averaged under two per system, the CWS was originally designed as a sample of systems, where every well in a selected system would be sampled. The results of the pilot survey indicated that many systems interpreted this variable to mean ground water and surface water as two water sources, regardless of how many wells or streams were being used. The average number of wells for the systems included in the pilot sample was five-and-a-half. Multiple wells from the same system are likely to much closer together than wells from different systems and therefore more correlated with regard to pesticide contamination. Thus it was decided to switch to a survey of wells used by community water systems.

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[1] Parts of the sample allocation procedure presented in this Appendix were originally presented in the Research Triangle Institute (RTI) report entitled "National Survey of Pesticide Results in Community System and Rural Domestic Wells – Sample Allocation Report," April 6, 1988, under EPA contract number 68-01-7350.

[2] National Pesticide Survey Pilot Evaluation Report, Office of Drinking Water and Office of Pesticide Programs, U.S. EPA, September 1987.

The CWS pilot survey also discovered that in at least one state, California, the FRDS file contained numerous multiplicities. Some of the "systems" on FRDS were actually water companies that operated many smaller community water systems that could be located many miles from each other and administered separately. It was also possible for a system to be listed twice, once by itself and once as part of a larger water company. Finally, some systems had merged with other systems over time.

Finally, the pilot survey found ineligible systems on the FRDS frame. Ineligible systems were caused by numerous factors. A system might no longer be operating; it might never have qualified as a community water system; or it might have been impossible to locate the system.

As a result of these findings it was decided that not all wells could be economically sampled from every sampled system; thus the CWS would be a survey of wells used by CWSs, not a survey of systems. The need to know how many wells a system used, combined with the need to sort out multiplicities, led to the use of a two-stage sample of CWSs for the main survey, with a screener survey conducted of the systems selected in the first-stage which tried to discover multiplicities, confirmed eligibility for the survey, and determined the number of wells used by the system.

In response to the SAP subpanel's concerns about temporal variability, the Survey design randomly assigned available time periods to the wells selected for sampling. This randomization was performed within the design strata and across the CWS well and rural domestic well surveys. Further details are provided in Section B5.

B2 First-Stage Stratification

The first-stage stratification was the same for the CWS and rural domestic well Surveys. Each of the 3,137 counties or county equivalents in the United States was categorized by pesticide use and ground-water vulnerability.

EPA developed pesticide use estimates for each county based on information about crop acreages from the 1982 Census of Agriculture and on private marketing data on pesticides (provided by Doanes Marketing Research, Inc.). Total acreage using 52 specific chemicals was calculated for 28 crops.[3] The list of chemicals used is provided in Exhibit B-1. Exhibit B-2 provides a list of the crops. The county-level use estimates were derived by a simple proportioning scheme. For each crop, data on acreage for that crop in each county in the United States (except Alaska) was extracted from the 1982 Census of Agriculture. The ratio of the county acreage for a crop to the corresponding regional acreage for that crop gave a proportion that was multiplied by the regional estimates of individual pesticides used on that same crop. Not all counties grow all of the 28 crops for which regional pesticide use data was obtained. Furthermore, not all pesticides are used on all crops nor is a pesticide used on a crop always used in all regions growing that crop. The estimation process assigned zeros to many of the estimates. A series of use estimates were prepared for each county and for each pesticide/crop pairing for which regional use data were available.

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[3] Derivation of County-Level Pesticide Usage Estimates For Design of the Groundwater Pesticide Survey, Economic Analysis Branch, Benefits and Use Division, Office of Pesticide Programs, September 1985.

Exhibit B-1
Chemicals Used for County-Level Characterization of Pesticide Use

Acifluorfen
Alachlor
Aldicarb
Ametryn
Atrazine
Bentazon
Bromacil
Butylate
Carbaryl
Carbofuran
Carboxin
Chloramben
Chlordane
Chlorothalonil
Cyanazine
Cycloate
Dalapon
DBCP
Dacthal
Diazinon
Dicamba
2,4-D
Dieldrin
Dinoseb
Diphenamid
Disulfoton
Diuron
EDB
Fenamiphos
Fluometuron
Fonofos
Hexazinone
Maleic Hydrazide
MCPA
Methomyl
Methyl Parathion
Metolachlor
Metribuzin
Oxamyl
Paraquat
PCNB
Picloram
Prometon
Pronamide
Propazine
Propham
Simazine
Trifluralin
Triallate
2,4,5-T
Tebuthiuron
Terbacil

Exhibit B-2
Crops Used for County-Level Characterization of Pesticide Use

Alfalfa
Corn
Cotton
Sorghum
Soybeans
Wheat
Pasture
Peanuts
Potatoes
Sweet Corn
Tomatoes
Tobacco
Sugar Cane
Sugarbeets
Sunflowers
Rice
Dry Beans and Peas
Walnuts
Pecans
Almonds
Apples
Pears
Peaches
Cherries
Plums and Prunes
Grapefruit and Oranges
Lemons
Grapes

The next step in the process was to do a simple summation of the county-level use estimates across all crops for each of the pesticides. This step provided county-level use by pesticide. The basic underlying assumption of this approach was that among growers of a crop in a region there is a homogenity of pesticide use practices. Summing the estimates and dividing by the total area of the county provided an index that could be used to compare the relative intensity of agricultural pesticude use among counties. Agricultural pesticide use was described as high, moderate, low, or uncommon, based on the following percent cut-offs.

- **High Pesticide Use**: Pesticides applied to 75 percent or more of the land area of the county.
- **Moderate Pesticide Use**: Pesticides applied to at least 30 percent and less than 75 percent of the land area.
- **Low Pesticide Use**: Pesticides applied to at least 5 percent and less than 30 percent of the land area.
- **Uncommon Pesticide Use**: Pesticides applied to less than 5 percent of the land area.

Within each of these levels of pesticide use, counties were further stratified according to their ground-water vulnerability.[4] Ground-water vulnerability was estimated using the Agricultural DRASTIC index. As described in Chapter 2, the DRASTIC Index is a numerical scoring system devised by the National Water Well Association (NWWA) based on the weights, ranges, and rating of seven factors. High scores were selected to represent areas where physical characteristics afforded little protection from ground-water pollution. An Agricultural DRASTIC Index was designed by NWWA for which the specific concern was the application of pesticides to the land surface. The Agricultural DRASTIC Index differs from the DRASTIC Index only in the assignment of different weights for the seven factors. The Agricultural DRASTIC Index places a higher weighting on topography (percent slope) and soil media than does the DRASTIC Index. Topography is important when considering the application of pesticides to the land surface because slope controls the likelihood that a pollutant will run off or remain on the land surface in one area long enough to infiltrate. The attenuating processes (filtration, biodegradation, sorption, or volatilization) that may be available in the upper few feet of the soil media can also influence the migration of pesticides.

Although the DRASTIC system was designed by NWWA as a screening tool for county-size areas down to a resolution of approximately 100 acres, an application of a modified system was considered suitable for the county-level assessment needed to meet the first stage of stratification of the National Pesticide Survey. Recognizing the physical variation that exists in areas as large as counties, a county data collection form was designed that allowed each factor to be coded on a percentage basis.

Coders performed DRASTIC scoring using two slightly different approaches that were reviewed and coordinated in quality control procedures. In one, the seven hydrogeologic factors for each county were divided among several coders so that a few coders ranked the factors dealing with geologic criteria (depth to water, aquifer media, impact of the vadose zone media, and hydraulic conductivity), others ranked soils, and others ranked the topography and net recharge. The composite numerical score for each county coded using this system may have, therefore, resulted from the combined efforts of at least three individuals. This division of labor was intended to promote consistency in the coding of specific hydrogeologic factors among counties. Hydrogeologic factors such as depth to water, aquifer media, soil media, and vadose zone media were ranked based on literature review and conversations with State and regional representatives (e.g., State Geological Surveys, U.S. Geological Survey, and Soil Conservation Service). Net recharge was ranked based on a formula to incorporate information on surface water baseflow, published recharge rates, precipitation, topography, and soil media. Topographic slope was determined using USGS 2° Topographic Maps (1:250,000) and a standardized slope estimation technique. Hydraulic conductivity estimates for each county were based on literature review, the contractor's knowledge of the aquifer media, and general ranges of hydraulic conductivity.

The second system assigned entire States to individual coders. Each coder was therefore responsible for ranking all seven hydrogeologic factors for every county within a State. Such an approach was used to promote overall consistency among the DRASTIC scores of all the counties within a State. Six of the seven DRASTIC factors (all but topography) were ranked in this system based on literature review, discussions with State and regional representatives, and the applicable field experience of the coder. Topographic slope was estimated based on information from USGS 2° Topographic Maps and from individual State general soils maps.

The quality control process randomly selected 7% of the counties after coding and assigned them for recoding to coders who followed the other approach. A total variable measurement error estimate then was computed. In addition, a randomly chosen set of this subsample was also recoded by the prime contractor. Finally, 6 counties were coded by several nationally recognized hydrogeologists as a qualitative check.

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[4] Ground-Water Vulnerability Assessment In Support Of the First Stage of the National Pesticide Survey, Research Triangle Institute, February 14, 1986.

Originally-coded county data were edited for completeness, correctness, and legibility. The majority of the fields on the forms were found to be complete but occasional omissions were not uncommon for a given DRASTIC factor. The forms were examined for correctness with respect to the percentage allotted for a given factor.

Following the editing process, the forms were screened for reasonableness. Total numerical scores were compared with those of adjacent counties or States, and the individual DRASTIC factors were compared for reasonable agreement on a given form. General agreement between aquifer media, the impact of the vadose zone, and the hydraulic conductivity was found in many instances. Completed forms were occasionally reviewed for reasonableness with respect to known regional hydrogeologic conditions by independent reviewers.

Upon completion of the editing and preliminary review process, all fields on the forms were keyed and the forms were verified by the key operators. The keyed data were copied to EPA's National Computer Center (NCC) at Research Triangle Park. Data were read from tape into Statistical Analysis System (SAS) data sets.

Three numerical scores were calculated from the data set:

- **Total Score.** An unweighted score corresponding to the summation of the highest percentage for the seven DRASTIC factors.
- **Weighted Score.** A weighted score corresponding to the summation of all percentage ratings for the seven DRASTIC factors. The weighted score accounts for the variability that occurs in areas as large as counties. In counties with little variability, little difference exists between the total score and weighted score.
- **VARSCORE.** Represents the weighted score including (+ or -) the index of variability, where used. The VARSCORE or the adjusted VARSCORE is considered to be the most appropriate score for the purposes of the NPS in that it best accounts for intracounty variability.

The index of variability was used because the Agricultural DRASTIC Score that was determined is based on typical values that do not account for heterogeneities such as degree of fracturing in the aquifer media or the vadose zone. The term referred to as "index of variability" can be used to indicate the hydrogeologist's opinion on the variability that might be associated with the previously determined score. Aquifer media and the impact of the vadose zone are the primary DRASTIC factors where index of variability may apply.

Ground-water vulnerability was classified as high, moderate, or low, separately within each level of pesticide use. The proportions of high, moderate, and low ground-water vulnerability could then be set equally for each level of pesticide use. The high ground-water vulnerability stratum contained approximately 25 percent of all households with wells, as did the low ground-water vulnerability stratum. The middle group is about twice as large as either of the other two. (These numbers are not exact as the DRASTIC index was scored for whole counties and, for instance, counties were included in the high ground-water vulnerability stratum when the number of corresponding households with wells was nearest to 25%.) Three groups of counties are identified by ground-water vulnerability within each pesticide stratum. The stratum definitions are summarized in Exhibit B-3. The actual DRASTIC index values that define the ground-water vulnerability strata are also included in this exhibit.

Exhibit B-3
Strata for the NPS First-Stage Survey Design

Agricultural Pesticide Use	Ground-Water Vulnerability	Defining DRASTIC Scores
High	High Moderate Low	148 and over 116 to 147 115 and under
Moderate	High Moderate Low	163 and over 113 to 162 112 and under
Low	High Moderate Low	159 and over 132 to 158 131 and under
Uncommon	High Moderate Low	152 and over 121 to 151 120 and under

From this point, the CWS and rural domestic well surveys follow separate, though sometimes similar, paths. The CWS well survey design is further detailed in the next section, while further details of the rural domestic well survey are provided in Section B4.

B3 CWS Well Survey Design

The sampling design for the CWS survey was originally a stratified, two stage design for community water systems. As the Survey developed, recommendations were made for changing the CWS survey from a survey of community water systems to a survey of CWS wells. As a survey of wells, the CWS survey is regarded as a three stage design where the third stage of the design selects a well from the systems sampled at the second stage. This section presents elements of the original design and the design changes that were made as a result of the change in target populations. The first stage stratification for the Survey was presented in the previous section. The stratum sizes in terms of the number of community water systems in the population are presented in Exhibit B-4.

Section B3.1 outlines the precision requirements in terms of variance constraints imposed on the two CWS domains of interest. Sections B3.2 and B3.3 outline the variance and cost components of the optimization procedure used to determine the desired sample sizes. The optimization procedure is explained in Section B3.4. Section B3.5 explains non-response adjustments to the sample allocation. To this point, the discussion concerns the sample allocation according to the design requirements. Section B3.6 and B3.7 describe some of the implementation problems and the actual survey design that was used.

Exhibit B-4
Community Water System First Stage Stratum Sizes

Pesticide Use Stratum	Vulnerability Stratum	Number of FRDS Records*
High	High	1,310
	Moderate	2,669
	Low	1,432
Moderate	High	2,183
	Moderate	3,352
	Low	2,559
Low	High	3,578
	Moderate	7,199
	Low	5,545
Uncommon	High	3,472
	Moderate	9,511
	Low	7,961
Total	High	10,543
	Moderate	22,731
	Low	17,497
High	Total	5,411
Moderate	Total	8,094
Low	Total	16,322
Uncommon	Total	20,944
Total	Total	50,771

* Entries are the numbers of FRDS records that are identified as active community water systems with at least one well or ground-water source operated by the system. Seven records for which county identification was missing are excluded.

Source: Mason, R.E., C.H. Benrud, and V.G. Iannacchione. Stratification Proposed for the National Pesticide Survey, Research Triangle Institute, Report No. RTI/3030/03-06F, 1986.

B3.1 Precision Requirements

The sampling design for the CWS Survey was initially developed to provide estimates for drinking water systems rather than the individual wells. Original expectations were that the number of wells per system would average about 1.5. However, the NPS pilot survey indicated an average of about 6 wells per system. Accordingly, individual CWS wells replaced active community water systems as the basis for the design.

The precision requirements were stated in terms of the maximum values of the sampling variances to be associated with estimates of system level proportions of a specified size.[5] As a result of the SAP subpanel recommendations, the precision requirements were changed to represent constraints on well level proportions.[6] It is these constraints that are presented in Exhibit B-5. The relative domain size is an assumed percentage of all CWS wells in the population that contain at least one Survey analyte. For example, 0.5% of all CWS wells were assumed to contain detectable levels of at elast one pesticide. The precision requirements are specified in terms of the variances to be associated with sample estimates for the specified relative domain sizes. Separate variance constraints were imposed on the two CWS domains of interest, as Exhibit B-5 indicates.

Exhibit B-5
Precision Requirements for the Community Water System Well Survey

Domain Description	Item	Value
1. CWS wells nationally	Relative domain size Relative standard error Detection probability Confidence interval	0.005 0.658 0.90 0.0 - 0.012
2. CWS Wells in counties with high ground-water vulnerability	Relative domain size Relative standard error Detection probability Confidence interval	0.001 1.040 0.60 0.0 - 0.003

They can be interpreted as follows, for example:

- The relative standard error for the detection of pesticides in CWS wells nationally in 0.658;
- Requiring a 90% probability of detecting the presence of at least one pesticide in the sample of CWS wells nationally if 0.5% of such wells contain pesticides;
- The 95% upper confidence bound for the proportion of CWS wells nationally that contain pesticides is 1.2% if 0.5% contain pesticides; and[7]

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[5] Mason, R.E., et al., 1988, National Pesticide Survey Pilot Evaluation Technical Report, Research Triangle Institute, report number RTI/7801/06-02F, 405 p.

[6] Mason, R.E., and Lucas, R.M., 1988, National Survey of Pesticide Residues in Community System and Rural Domestic Wells, Sample Allocation Report, Research Triangle Institute, report number RTI/7801/04-04F. Terms used in this report have been retained for purposes of consistency and documentation.

[7] Confidence intervals were not design requirements and were calculated using a normal distribution approximation.

- Requiring a 60% probability of detecting the presence of at least one pesticide in the sample of CWS wells in counties with high vulnerability if 0.1% of CWS wells nationally are in counties with high vulnerability and contain pesticides.

Other quantities derived from the variances were used to evaluate alternative survey designs and are presented in Exhibit B-5. They are:

1. **Relative Standard Errors.** The proportion that the square root of the variance (the standard error) is of the relative domain size (also referred to as the coefficient of variation):

$$RSE\,(\hat{P}_d) = \left[VAR\,(\hat{P}_d)\right]^{1/2} / \hat{P}_d$$

2. **Detection Probabilities.** The proportion of repeated samples of size θ (using sample random sampling) in which at least one well in that domain containing pesticides is observed:

$$DP\,(\hat{P}_d) = 1 - \left[1 - \hat{P}_d\right]^{\theta}$$

where

$$\theta = \frac{\hat{P}_d(1 - \hat{P}_d)}{VAR\,(\hat{P}_d)}$$

3. **Confidence Intervals.** The proportion of repeated samples for which the computed interval contains the relative domain size (in this case, approximate 95% confidence intervals). The lower bound of the confidence interval is the value, $\hat{P}_L$, that most nearly satisfies the equality in the constraint:

$$\sum_{i=a}^{\theta} \binom{\theta}{i} \hat{P}_L^{\,i} \left(1 - \hat{P}_L\right)^{\theta - i} \leq 0.025$$

and the upper bound of the confidence interval is the value, $\hat{P}_u$, that most nearly satisfies the equality in the constraint:

$$\sum_{i=0}^{a} \binom{\theta}{i} \hat{P}_u^{\,i} \left(1 - \hat{P}_u\right)^{\theta - i} \leq 0.025$$

The estimates, $\hat{P}_d$, used in the above equations are the assumed relative domain sizes (indexed by d for the domain). θ is a surrogate for the sample sizes required to satisfy the precision constraints, and a is the sample estimate of the number of wells containing at least one pesticide.

The formulas are presented assuming that the underlying distribution for the relative domain size is binomial. In fact, the populations are finite so the underlying distribution is hypergeometric, but the population sizes are large enough that use of the binomial distribution approximation to the hypergeometric distribution is appropriate. The confidence intervals presented in Exhibit B-5 used the normal distribution approximation to the binomial distribution. When the proportions are extremely small this approximation is not justified and the binomial distribution should be used directly. Relative standard errors and detection probabilities presented in Exhibit B-5 are a more accurate reflection of the precision requirements for the Survey.

The CWS survey design can be regarded as a three stage design, where the first and second stage sampling units are community water systems and the third stage sampling units are CWS wells. Initially a large first stage sample was selected with conditionally equal probabilities, given the design stratum. This sample is termed the "screener" sample. The number of operable wells contained in each of these systems was determined by talking with the system operators. Given this information, a second stage subsample of systems was selected with probability proportional to number of operable wells in the system. This sample is termed the "main" sample. At the third stage, a single sample well was selected at random from each system in the main (second stage) sample. (Note that if a system was selected twice at the second stage then two wells were selected at the third stage, etc.)

The sample allocation model takes the three design stages into account. That is, appropriate sample sizes were calculated for each stage based on the precision requirements (the sample sizes are the same at the second and third stages). The procedure for calculating the sample sizes necessary to satisfy the precision requirements for the CWS well survey required two components, a variance model that accounts for the precision requirements and the three design stages, and a cost model. Section B3.2 describes the variance model; section B3.3 describes the cost model. Output from these two models, the variance constraints and the cost estimates, were used in a nonlinear programming procedure based on Kuhn-Tucker constrained optimization theory to derive the sample allocation that satisfies the precision requirements for the minimum cost. Application of this procedure is described in Section B3.4.

B3.2 Variance Model for the CWS Well Survey Design

The estimator of the mean proportion of CWS wells with detectable levels of at least one pesticide that was used to design the Survey was modeled within each domain as:

$$\hat{P}_d = \sum_{i=1}^{12} \sum_{j=1}^{N(i)} S(i,j)\, \hat{P}_d(i,j) \,/\, N$$

where the subscript d denotes the domain of interest (either CWS wells nationally or CWS wells in counties with high ground-water vulnerability); i indexes the twelve first stage strata (see Exhibit B-3); j indexes the community water systems within strata; N represents the total number of community water systems (assumed N=50,771); $N(i)$ represents the number of community water systems contained in the i^{th} first stage stratum (see Exhibit B-4); $S(i,j)$ represents the number of wells contained in the j^{th} system in the i^{th} strata; and $\hat{P}_d(i,j)$ represents the estimate of the proportion of wells in domain d with detectable levels of at least one pesticide in the $(i,j)^{th}$ stratum.

The variance ($VAR(\hat{P}_d)$) can be expressed as the sum of the variance components associated with the two stages of sampling as follows:

$$VAR(\hat{P}_d) = \sum_{i=1}^{12} \left[\frac{V_1(\hat{P}_d(i))}{n_1(i)} + \frac{V_2(\hat{P}_d(i))}{n_2(i)} + \frac{V_3(\hat{P}_d(i))}{n_2(i)} \right]$$

where:

$\hat{P}_d(i) = \sum_{j=1}^{N(i)} S(i,j)\, \hat{P}_d(i,j) / N(i)$ = estimated proportion of all CWS wells that are in first stage stratum i of domain d, and have detectable levels of at least one analyte.

$$V_1(\hat{P}_d(i)) = \left[\frac{N(i)}{N_d}\right]^2 \sigma^2(i)\, \rho\, f(k)$$

$$V_2(\hat{P}_d(i)) = \left[\frac{N(i)}{N_d}\right]^2 \sigma^2(i)\, \rho\, f(k)$$

$$V_3(\hat{P}_d(i)) = \left[\frac{N(i)}{N_d}\right]^2 \sigma^2(i)\, g(k)$$

$$\sigma^2(i) = P_d(i)\,(1 - P_d(i))$$

$P_d(i) = \sum_{j=1}^{N(i)} S(i,j)\, P_d(i,j) \,/\, N(i)$ = proportion of all CWS wells that are in first stage stratum i of domain d, and have detectable levels of at least one pesticide.

ρ = intracluster correlation among wells within systems.

$f(k), g(k)$ are functions of the distribution of the number of wells per system assumed for the CWS well survey design (see Exhibit B-6 below).

$n_1(i)$ denotes the number of community water systems selected into the first stage (screener) sample.

$n_2(i)$ denotes the number of community water systems selected into the second stage (main) subsample.

The first variance component (V_1) represents the variance associated with the first stage of sampling (i.e., sampling systems from the population).

The second variance component (V_2) represents the variance associated with the second stage of sampling (i.e., sampling systems from the first stage subsample).

The third variance component (V_3) represents the variance associated with the sampling of only one well from each of the second stage subsamples.

Exhibit B-6 shows the assumed distribution of the number of wells per system used in the community system design. The factors *f(k)*, *g(k)* are defined with respect to this exhibit as:

$$f_1(k) = \sum_k \left[\frac{M(k)}{m}\right]^2 R(k) \left[1 - \frac{1}{M(k)}\right] / M(k)$$

$$f_2(k) = \sum_k \left[\frac{M(k)}{m}\right] R(k) \left[1 - \frac{1}{M(k)}\right] / M(k)$$

and

$$g(k) = 1 - \frac{1}{m}$$

Exhibit B-6
Assumed Distribution of the Number of Wells Per System Used in the Community System Design

Group Index Value (k)	Mean Number of Wells in Group K (M(k))	Percent Relative Frequency of Number of Systems (R(k))
1	1	22.0 %
2	2	31.7 %
3	3	17.1 %
4	4	7.3 %
5	5	7.3 %
6	10.5	14.6 %
Total:	-	100.0 %
Mean (m)	3.56	-

The estimated values of *M(k)*, *R(k)*, and *m* are based on the results of the pilot study, which was the only reliable information available. For instance, 22.0% of community water systems have 1 well, and 14.6% of systems have more than 5 wells. The average number of wells per system is 3.56, and the average number of wells per system for systems that have at least 6 wells is 10.5. The value of ρ was assigned to be 0.1 for all strata and both domains. This assumed intracluster correlation was the most arbitrary part of the sample allocation process. If a smaller value of ρ had been specified then the variance constraints could be achieved with a smaller sample size. If a larger value had been specified, then a larger sample size would be required.

B3.3 Cost Model for the CWS Well Survey

Costs were estimated to calculate a cost efficient sample size that would achieve the precision requirements specified by EPA. Actual costs of the Survey were different than these initial estimates. The cost model for the CWS well survey was specified in the form:

$$C(\underline{n}) = \sum_{i=1}^{12} \left[n_1(i)C_1(i) + n_2(i)(C_2(i) + C_3(i)) \right]$$

where $n_1(i)$ and $n_2(i)$ are the sample sizes for the first stage (screener) sample and the second stage (main) sample, $C(\underline{n})$ denotes the total cost of the survey (the vector $\underline{n}$ represents the sample sizes for the first two design stages and all twelve first stage strata), and

$C_1(i)$ = the first stage per system cost ($13.21) of sampling frame construction and stratification, sample selection, data collection, and data processing and analysis averaged over all systems in the i^{th} stratum;

$C_2(i)$ = the second stage cost per system ($508.19); and

$C_3(i)$ = the average third stage cost per well ($3,013.84) of sampling and collecting, preserving, transporting, and chemically analyzing the water samples.

B3.4 Sample Allocation for the CWS Well Survey

Given the variance constraints and the cost component, a nonlinear programming procedure based on Kuhn-Tucker constrained optimization theory was used to derive the sample allocation that achieves the precision requirements for the minimum cost.

This procedure can be expressed as minimizing the following function:

$$F(\underline{n}) = C(\underline{n}) + \sum_{d=1}^{2} \lambda_d \left[Var\,(\hat{P}_d) - V_d \right]$$

where:

λ_d = a LaGrange multiplier for the d^{th} domain corresponding to the d^{th} precision constraint.

V_d = variance constraint imposed for the d^{th} domain (as given in Exhibit B-5).

The sample size solutions are found by taking partial derivatives with respect to the sample sizes $n_1(i)$ and $n_2(i)$, equating to zero and solving. The solutions take the following form:

$$n_1(i) = \left[\frac{\sum_{d=1}^{2} \lambda_d \, V_1(\hat{P}_d(i))}{C_1(i)} \right]^{1/2}$$

$$n_2(i) = \left[\frac{\sum_{d=1}^{2} \lambda_d \, [V_2(\hat{P}_d(i)) + V_3(\hat{P}_d(i))]}{C_2(i) + C_3(i)} \right]^{1/2}$$

The sample sizes for each stratum required to achieve the specified precision are presented in Exhibit B-7. A total of 5,872 wells were required for the screener survey and a subsample of 564 of those wells was required for the main survey.

Exhibit B-7
Sample Allocation for the Community Well Survey

Stratum Number	Pesticide Use	Groundwater Vulnerability	First Stage Sample Size	Second Stage Sample Size
1	High	High	264	25
2		Moderate	249	24
3		Low	134	13
4	Moderate	High	439	42
5		Moderate	313	30
6		Low	239	23
7	Low	High	720	69
8		Moderate	671	65
9		Low	517	50
10	Uncommon	High	698	67
11		Moderate	887	85
12		Low	742	71
Total			5,872	564

B3.5 Expected Non-Response Adjustments to the Sample Allocation

The sample size allocation presented in Exhibit B-7 is the minimum number of wells in each strata that is necessary to achieve the design specifications for the survey. The sample sizes presented for both the first stage (screener) survey and the second stage (main) survey needed to be inflated to account for potential non-response.

Any failure to obtain complete information, including eligibility information, water samples, or questionnaire data, from a selected system results in a non-response. Examples of non-response include failure to locate a system, or lack of cooperation of system operators. Initial estimates of non-response rates were revised subsequent to results of the pilot study, and incorporation of the screener survey into the survey design.

Exhibit B-8 presents the number of wells that were included in the CWS well survey after a non-response factor has been taken into account. For instance, 7,086 systems were selected for the screener survey, of which 5,872 were expected to be eligible. Similarly, 599 wells were in the main survey. Note, these numbers reflect design parameters. As explained in the following section the actual implementation used slightly different values.

Exhibit B-8
Sample Sizes for the CWS Well Survey

Stratum	Pesticide Use	Ground-Water Vulnerability	First Stage Sample Size[a]		Second Stage Sample Size	
			Required	Adjusted	Required	Adjusted
1	High	High	264	293	25	27
2		Moderate	249	277	24	25
3		Low	134	148	13	14
4	Moderate	High	439	556	42	45
5		Moderate	313	355	30	32
6		Low	239	265	23	24
7	Low	High	720	867	69	73
8		Moderate	671	772	65	69
9		Low	517	647	50	53
10	Uncommon	High	698	776	67	71
11		Moderate	887	1,069	85	90
12		Low	742	1,061	71	76
Total			5,872	7,086	564	599

[a] Sample sizes required to achieve survey precision requirements and adjusted sample sizes that account for expected non-response.

B3.6 Screening Procedures for Community Water System Wells

The sampling frame for the community water system survey was the 1984 Federal Reporting Data System (FRDS) database. FRDS includes the name, address, and selected information on all CWSs reported by State. The 1984 file was the most recently available version of FRDS at the time of the selection. Federal money is available for CWSs listed on FRDS, thus providing an incentive for complete reporting. There is no comparable incentive for eliminating inoperative systems. Therefore it was assumed that FRDS contained a complete list of CWSs (except those created since 1984) but also could contain systems that were not eligible for the survey. Within each stratum the CWSs on the FRDS frame were sorted by EPA Region, then State, and finally by their public water system identification number (also referred to as their FRDS ID or PWS ID). The frame for the CWS survey was known to contain records of non-CWSs (e.g., systems that no longer produced drinking water) mixed among the CWSs. The pilot survey also found that there were no reliable data on the number of wells in a system on the frame. There was also the possibility of multiplicities on the frame, both one system being reported twice and one "system" reporting for multiple actual systems. It was therefore necessary to conduct a screener survey to verify and clean up the information on the frame. This was carried out on a large sample of CWSs.

The sample that was screened included the oversampling of systems in the most vulnerable counties. From those that were found to be eligible, a systematic sample of systems was selected with replacement with probabilities proportional to the number of wells within each system. One well was then selected from within each system. This combination of probabilities resulted in a sample that was close to having all wells having the same probabilities of selection (except for the oversampling in vulnerable counties). A systematic random sample was then selected of the size specified in Exhibit B-8.

Using FRDS it was possible to identify 50,771 systems that reported using ground water as a source of drinking water. The first step was to assign each CWS to a county so as to place each system into one of the twelve first-stage strata. This was done as part of the pilot survey. When interpreting the results of the CWS survey for the "most vulnerable counties" domain, it is important to remember that the county is assigned based upon the mailing address for the system, usually where the administrative office is located. In general this office is located near the CWS well(s). It is possible, however, especially in large systems, for individual wells to be located in a different county from the mailing address of the administrative office. For example, one system with a mailing address in Reno, Nevada had wells in the Lake Tahoe region.

Lists of the selected community water systems were sent to the appropriate EPA Regional offices, and forwarded by them to the States for review before screening telephone calls commenced. The purpose of the State review was two-fold: to permit the States to notify the selected systems of the imminent telephone calls, if they desired; and to have the States identify any errors in the names, addresses and telephone numbers of the sampled systems. The States were not asked to comment on the appropriateness of including the system in the sample.

While many States submitted minor changes to the screener sample, it was discovered that there were major problems with the FRDS data for California. Specifically, a number of the systems on the frame for California turned out not to be community water systems. In addition, there were no small community water systems on the frame, only large systems (200 or more connections). The nature and extent of these frame errors, concentrated in one State, required that the screening survey sample be corrected.

California officials had discovered this problem with their 1984 FRDS data and had submitted a revised data set, but this revision had not been incorporated into FRDS when the original design of specific sample sizes for the screener and main survey samples was prepared. This problem became known during the pilot survey, but could not be rectified before the beginning of the main survey. To correct the screener sample, a stratified sample of systems was selected from the revised California FRDS data set using the same sampling rates, and adjusting for non-response, as in the earlier data base. This resulted in a final screener sample of

6,814 systems (rather than 7,086) after adjusting for non-response. Similarly, the adjustments to the screener survey size affected by the relative proportions of CWS from California led to a new desired eligible sample size of 5,648 systems.

The screener survey found 5,660 of the 6,814 systems surveyed were eligible community water systems willing to participate in the main survey. The screener achieved a 96.9 percent response rate, with almost all non-response caused by non-locatable cases even after extensive tracing (i.e., 96.9 percent of the 6,814 systems surveyed were respondents). Four percent of the screener sample was found not to qualify as a CWS. A large percent (over 10 percent) of the ineligible cases contained out-of-date or incorrect contact information. Without extensive tracking procedures (see Appendix C for more details) these would all probably have been deemed out of business. The tracking procedures determined that one percent had definitely gone out of business and another three percent could not be traced or located and, therefore, were assumed to be out of business. For more details on the procedures used to contact these systems see Appendix C.

B3.7 CWS Main Survey Sample Selection

A minimum sample of 564 completed CWS well samples was necessary to meet the original design's accuracy requirements given the assumed rates of detection. Because all CWSs are required by law to allow their water to be tested it was assumed that there would be only a 5 percent non-response and ineligibility rate with this sample. The 5% was applied separately within each of the 12 first stage strata. This corresponded to an initial sample size of 599 CWS wells.

The 5,660 eligible community water systems were sorted as for the screener survey, by EPA Region and State. The systematic selection of wells for the main survey sample used probabilities proportional to size, where the number of drinking water wells reported in the screener survey was used as the measure of size. Community water systems that had refused to cooperate on the screener, or for which language problems had prevented the gathering of information, were assumed to be eligible and given a measure of size equal to one well. This subset of the non-respondents corresponded to 36 of the 6,814 systems.

Community water systems with a large number of wells were selected for the main survey with certainty. The certainty cut-off was determined for each stratum by taking the total number of wells divided by the number of sampled wells to be selected. All systems exceeding these cut-offs were placed together in the systematic sorting procedure and given a chance of being selected multiple times. The number of times a system was selected determined the number of wells to be tested at the system. For example, assume the certainty cut-off in a given stratum is 30.0 and that one community water system has 72 wells. Since 72/30=2.4, a systematic sample with a random start has .4 probability of selecting the system 3 times and .6 probability of selecting the system 2 times. If it was selected 3 times, then 3 of the 72 wells were sampled; if it was selected twice, then 2 of the 72 wells were sampled.

EPA used a random well selection procedure for each selected CWS system to determine the one well to be tested. A sequence of random numbers was selected for each system (up to a maximum of 6 random numbers for a system) that reported more than one well on the screening survey. The interviewers obtained a listing of the wells in the system and then selected the well corresponding to the first random number on the list. If that well was not able to be sampled (e.g. no sampling port available pre-treatment), the interviewer was to select the well corresponding to the second random number. This procedure continued until all six numbers had been attempted. If none of these wells could be sampled, then the interviewer was to proceed through the list one well at a time (beginning with the sixth random number), until a well was finally selected that could be sampled.

When a system was to be sampled multiple times, the above procedure only applied to the first visit. The CWS Field Director randomly selected the well to be sampled for all successive visits, telephoning the CWS to confirm its ability to be sampled.

During the CWS survey a number of questions arose over the eligibility of certain wells for inclusion in the NPS. Some well owners used chlorine to purify their well water, and useful water samples could not be taken from such wells because the laboratory analyses could not be accurately performed on water containing chlorine. Wells for which no sampling port was available prior to chemical treatment could not have samples drawn from them. In some systems, the water from several wells was co-mingled in common pipes (tubular well systems). Because it was impossible in such cases to allocate the attributes of the water to the individual wells, these systems could not be sampled as part of the survey, but were still considered part of the target population.

During the field period it became apparent that the target sample size of 564 wells would not be achieved. More wells than anticipated were ineligible or impossible to sample in the field. There were a number of reasons for this. In some cases the number of wells reported on the screener far exceeded those found at the time of sampling. There were numerous wells with chlorine problems or which were part of tubular systems. For some wells, a port was not available from which to draw a water sample prior to the point of chemical treatment. Some well owners refused to participate in the survey; these amounted to about one percent of the sample. Other data were lost to quality control failures associated with taking water samples. It was estimated that the original sample of 599 wells would only provide approximately 512 completed samples. The shortfall was most pronounced in stratum 12; with a more moderate impact in strata 8, 9, and 10; and only a minor impact on the other eight strata. These three strata groupings were treated separately for selection of a supplemental sample. The supplemental sample that was selected was large enough to increase the final number of expected completed samplings to the minimum sample size of 564 wells. The estimated shortfall was determined for each stratum, and inflated by the appropriate percent for each sample to account for ineligibles and wells impossible to sample. This resulted in a supplemental sample of 67 wells.

In order to minimize the response burden on any CWS a procedure was used that minimized the probability of selecting systems for the supplemental sample that were already part of the original sample. This was achieved in two steps. First, rather than selecting an independent random start (RS) for the supplemental sample, the random start for the original sample plus (or minus) one-half of the original interval (I) was used. The supplemental skip interval was set equal to a multiple of the original interval. In formulas (with primes for the supplemental sample):

$$RS' = \begin{cases} RS + I/2 \text{ if } RS \le I/2 \\ RS - I/2 \text{ if } RS > I/2 \end{cases}$$

and

$$I' = kI$$

where

$$k = \begin{cases} 3 \text{ if } stratum = 12 \\ 7 \text{ if } stratum = 8, 9, \text{ or } 10 \\ 21 \text{ for all other strata} \end{cases}$$

where *RS* represents the random start number; *I* represents the sampling interval (i.e., one system is selected out of every *I* systems), and *k* is a stratum dependent constant that determines how many more systems are selected for each stratum.

A system could be selected in both samples only if its number of wells exceeded I/2 and happened to be the 1, $k+1$, $2k+1$, etc. element of the original sample.

At the time the supplemental sample was selected there were only 8 weeks left in the data collection period. The supplemental sample in each stratum was then allocated evenly among the remaining four two-week sampling periods (see Section 5 for further details on the revised temporal allocation).

A total of 592 eligible wells were selected as part of either the original or supplemental samples. Water samples were successfully analyzed from 540 of these wells, giving an overall response rate of 91.2 percent. Stratum level response rates varied from a high of 97.4 percent in stratum 4 to a low of 85.7 percent in stratum 3 (the smallest stratum with only 14 eligible sampled wells).

B4 Rural Domestic Well Survey Design

The original survey design for the rural domestic well survey was a three stage design with stratification imposed on the first and second stages. The first stage stratification was described in Section B2. Unlike the CWS survey, where the first stage sampling units were systems, the first stage sampling units in the rural domestic well survey were counties (or county equivalents). Second stage sampling units for the rural domestic well survey were county subregions (enumeration districts and block groups) constructed within the sample counties. The subregions comprised mutually exclusive and exhaustive partitions of the total rural areas defined for the Survey. The subregions defined two levels: more and less heavily "cropped and vulnerable" areas. The third stage sampling units were operable rural domestic wells.

The first stage stratum population sizes are presented in Exhibit B-9. The total number of rural domestic wells was assumed to be approximately 13,102,00 for the purposes of calculating sample sizes necessary to achieve Survey precision requirements. This number was obtained from the 1980 Census.

Section B4.1 outlines the precision requirements in terms of variance constraints imposed on the five rural domestic well survey domains of interest. Sections B4.2 and B4.3 outline the variance and cost components of the optimization procedure used to determine the desired sample sizes. The optimization procedure is explained in Section B4.4. Section B4.5 explains non-response adjustments to the sample allocation. To this point, the discussion concerns the sample allocation according to the design requirements. Section B4.6 discusses the final survey design. The final design includes several changes in well selection procedures, such as the incorporation of random digit dialing at the second stage, and its effect on sample allocation.

Exhibit B-9
Rural Domestic Well Survey First Stage Stratum Sizes

Pesticide Use	Ground-Water Vulnerability	Number of Counties	Number of Rural Domestic Wells (thousands)	Number of Rural Domestic Wells in "Cropped and Vulnerable Areas" (thousands)
High	High	106	455	114
	Moderate	234	916	229
	Low	129	440	110
Moderate	High	110	684	171
	Moderate	204	1,417	354
	Low	267	671	168
Low	High	193	1,154	289
	Moderate	375	2,270	568
	Low	404	1,170	293
Uncommon	High	186	1,034	261
	Moderate	513	1,894	474
	Low	416	997	249
Total	High	595	3,327	835
	Moderate	1,326	6,496	1,625
	Low	1,216	3,279	820
High	Total	469	1,810	453
Moderate	Total	581	2,772	693
Low	Total	972	4,594	1,150
Uncommon	Total	1,115	3,926	984
Total	Total	3,137	13,102	3,280

B4.1 Precision Requirements for the Rural Domestic Well Survey

The precision requirements for the rural domestic well survey were stated in terms of specified acceptable variances for assumed proportions of rural domestic wells containing detectable levels of pesticides. Five domains of interest were specified for the rural domestic well survey. The corresponding precision requirements are given in Exhibit B-10. The interpretation of these requirements is similar to the interpretation described in Section B3.2 for the CWS well survey.

Exhibit B-10
Precision Requirements for the Rural Domestic Well Survey

Domain Description	Item	Value
1. All rural domestic wells in the United States	Relative domain size Relative standard error Detection probability Confidence interval	0.01 1.0 0.63 0.0 - 0.30
2. Wells in counties with highest average pesticide use	Relative domain size Relative standard error Detection probability Confidence interval	0.0014 1.85 0.75 0.0 - 0.004
3. Wells in counties with highest average ground-water vulnerability	Relative domain size Relative standard error Detection probability Confidence interval	0.0025 0.85 0.75 0.0 - 0.007
4. Wells in the "cropped and vulnerable" county subregions	Relative domain size Relative standard error Detection probability Confidence interval	0.0025 1.525 0.97 0.0 - 0.005
5. Wells in counties with highest average pesticide use and high ground-water vulnerability	Relative domain size Relative standard error Detection probability Confidence interval	0.0003 1.25 0.47 0.0 - 0.11

The rural domestic well component of the Survey was designed to yield a range of detection probabilities (relative standard errors, confidence intervals) for the different domains. The strategy was to employ a sampling design that provided greater chance of detection in domains of greater interest. The precision requirements yielded estimates of sample sizes that corresponded to comparative oversampling for these domains. For instance, the probability of detecting the presence of at least one pesticide in at least one well in the "cropped and vulnerable" domain was specified to be 97%. The corresponding probability of detection for the national domain was specified to be only 63%. To achieve the greater precision, the "cropped and vulnerable" domain had to be comparatively oversampled. The relative domain sizes presented in Exhibit B-10 correspond to the proportion of rural domestic wells in the nation that contain detectable levels of at least one pesticide and that are in the listed domain of interest. The listed variance constraints are calculated assuming a 0.01 proportion within each domain. The relative domain sizes are calculated as 0.01 multiplied by the proportion of wells in that domain. For further details of the relationships between variances, relative standard errors, detection probabilities, and confidence intervals see Section B3.2.

B4.2 Variance Model for the Rural Domestic Well Survey Design

The procedure for computing the sample sizes necessary to satisfy the precision requirements was generally the same as that for the CWS well survey. A variance model and a cost model were constructed and the optimal sample sizes were calculated that achieve the precision requirements (through the variance model) for the least cost.

The estimator of the mean proportion of rural domestic wells with detectable levels of at least one pesticide used for designing the Survey was modeled within each domain as:

$$\hat{P}_d = \sum_{i=1}^{12} \sum_{j=1}^{2} N(i,j)\ \hat{P}_d(i,j)\ /\ N$$

where

N	is the (assumed known) number of rural domestic wells nationally, N = 13,102,000.
$N(i,j)$	is the number of rural domestic wells in the i^{th} first stage and j^{th} second stage strata.
$\hat{P}_d(i,j)$	is the estimated proportion of rural domestic wells nationally that are in domain d and have a detectable level of at least one pesticide.

The variance of the sample estimate can be expressed as the sum of variance components associated with the three stages (V_1, V_2, V_3) of sampling as follows:

$$Var\ (\hat{P}_d) = \sum_{i=1}^{12} \left[\frac{V_1\ \{\hat{P}_d(i)\}}{n_1(i)} + \sum_{j=1}^{2} \left[\frac{V_2\ \{\hat{P}_d(i)\}}{n_1(i)n_2(i,j))} + \frac{V_3\ \{\hat{P}_d(i)\}}{n_1(i)n_2(i,j)n_3(i,j)} \right] \right]$$

where

$\hat{P}_d(i)$	is the estimated proportion of rural domestic wells nationally that are in domain d of the i^{th} stratum and have a detectable level of at least one pesticide.

$$V_1\ \{\hat{P}_d(i)\} = \left[\frac{N(i)}{N}\right]^2 \sigma^2(i)\ \rho_1$$

$$V_2\ \{\hat{P}_d(i)\} = \left[\frac{N(i,j)}{N(i)}\right]^2 \sigma^2(i,j)\,(1 - \rho_1)\,\rho_2$$

$$V_3\ \{\hat{P}_d(i)\} = \left[\frac{N(i,j)}{N(i)}\right]^2 \sigma^2(i,j)\,(1 - \rho_1)\,(1 - \rho_2)$$

$$\sigma^2(i) \quad = \quad P_d(i)\ [1 - P_d(i)]$$

$$\sigma^2(i,j) \quad = \quad P_d(i,j)\ [1 - P_d(i,j)]$$

$P_d(i)$	is the proportion of rural domestic wells nationally that are in the i^{th} stratum of domain d and have a detectable level of at least one pesticide.
ρ_1	is the intracluster correlation of detections of at least one pesticide within counties (intracounty correlation due to selecting clusters within counties).
ρ_2	is the intracluster correlation of detections of at least one pesticide within second-stage subcounty regions (intracluster correlation due to selecting wells within clusters).
$n_k(i)$	represents the sample sizes to be selected at the three stages of sampling ($k \in \{1, 2, 3\}$).

The variances $\sigma^2(i)$ and $\sigma^2(i,j)$, are computed using the specified relative domain sizes presented in Exhibit B-9 and the stratum sizes presented in Exhibit B-8.

The correlation parameters, ρ_1 and ρ_2 were assigned values 0.01 and 0.1, respectively, for all domains and strata.

B4.3 Cost Model for the Rural Domestic Well Survey

Costs were estimated to calculate a cost efficient sample size that would achieve the precision requirements specified by EPA. Actual costs of the survey were different than these initial estimates. The cost model used for designing the rural domestic well survey was specified as:

$$C(\underline{n}) = \sum_{i=1}^{12} \left[n_1(i) C_1(i) + \sum_{j=1}^{2} \left[n_1(i) n_2(i,j) C_2(i,j) + n_1(i) n_2(i,j) n_3(i,j) C_3(i,j) \right] \right]$$

where $n_1(i)$, $n_2(i,j)$, and $n_3(i,j)$ are the sample sizes for the first, second, and third stages of the survey; $C(n_1)$ denotes the total cost of the survey (the vector $\underline{n}$ represents the sample sizes at all stages of the Survey, at the first stage this is the number of counties; at the second stage, the number of subcounty regions (clusters); and at the third stage, the number of rural domestic wells).

$C_1(i)$	is the per county cost ($3,947) of sampling frame construction and stratification, sample selection, data collection and data processing averaged over all counties contained in the ith stratum;
$C_2(i,j)$	is the per subcounty region (cluster) cost ($678) similarly; and
$C_3(i,j)$	is the per well cost ($2,832) of sampling and collecting, preserving, transporting, and chemically analyzing the water samples.

B4.4 Sample Allocation for the Rural Domestic Well Survey

Given the variance constraints and the cost component a nonlinear programming procedure, similar to that used for the CWS well survey, was used to calculate the sample allocation that achieves the precision requirements at minimum cost. The method is described in Section B3.4. The sample size solutions take the following form:

$$n_1(i) = \left[\frac{\sum_{d=1}^{5} \lambda_d V_1(\beta_d(i))}{C_1(i)} \right]^{1/2}$$

$$n_2(i) = \left[\frac{C_1(i) \sum_{d=1}^{5} \lambda_d V_2(\beta_d(i,j))}{C_2(i,j) \sum_{d=1}^{5} \lambda_d V_1(\beta_d(i))} \right]^{1/2}$$

$$n_3(i) = \left[\frac{C_2(i,j) \sum_{d=1}^{5} \lambda_d V_3(P_d(i,j))}{C_3(i,j) \sum_{d=1}^{5} \lambda_d V_2(P_d(i,j))} \right]^{1/2}$$

The numerical solutions are obtained using the same iterative numerical procedures described for the CWS sample size allocation. These solutions are presented in Exhibit B-11. The first stage sample size is the number of counties in each stratum; the second stage sample size is the number of household clusters (block groups) within those counties; and the third stage sample size is the numbers of wells.

B4.5 Non-Response Adjustment to the Rural Domestic Well Sample Allocation Procedure

The sample allocation presented in Exhibit B-11 is the minimum sample size required to achieve the precision requirements of the survey design. The sample size had to be inflated to account for potential non-response. The sample allocation in terms of number of counties, subcounty regions, and wells and the inflated sample allocation are presented in the selected sample size column of Exhibit B-11.

For example, Exhibit B-11 shows that in the stratum corresponding to high pesticide use, high ground-water vulnerability, and "cropped and vulnerable" county subregions the sample sizes required to achieve the specified precision requirements are 7 counties, approximately 16 subcounty regions from those counties, and approximately 24 wells from those subcounty regions. The third stage selected sample size, for example, does account for non-response by inflating the second stage "cropped and vulnerable" stratum from 24 wells to 28 wells.

B4.6 Rural Domestic Well Selection

The pilot study carried out to assess the rural domestic well sample design and procedures for selecting wells for sampling were performed in the same states as the CWS well survey pilot study to minimize costs. Two counties each from California, Minnesota, and Mississippi were selected for the pilot survey from the 90 counties selected for the main survey.

Two adjustments were made to the rural domestic well survey based on the results of the pilot study. First, the stratum of "cropped and vulnerable" subcounty regions, which initially had been assigned within subcounty regions, was changed to a constant definition of "cropped and vulnerable" across the country as areas with either a DRASTIC score of at least 120 which were 50 percent cropped, or a score of 180 and 25 percent cropped. In the main survey sampling methodology for rural domestic wells, a constant definition of cropped and vulnerable areas was used throughout the country. In contrast the pilot survey had oversampled the most cropped and vulnerable parts of each sampled county. There were two reasons for this change. Use of the pilot procedure would have resulted in oversampling an area in one county that had identical characteristics to a non-oversampled area in another county, solely because of the conditions in the remainder of the county. Second, with this approach survey findings would treat two wells with similar ground water equally regardless of the county in which they were located.

Second, the method of selecting households for the main survey was revised. For the main survey random digit dialing (RDD) was used to select eligible households and then interviewers and water samplers were sent to the site only when it was time to conduct the survey. The telephone interview was also used to determined which second-stage stratum ("cropped and vulnerable" or "not cropped and vulnerable") applied for the well. In order to oversample "cropped and vulnerable" areas, only one-third of all eligible wells in the "not cropped and vulnerable" stratum were selected. Cropped and vulnerable areas were oversampled at a rate

Exhibit B-11
Sample Allocation for the Domestic Well Survey

First-Stage Sample			Second-Stage Sample			Third-Stage Sample	
Pesticide Use	Ground-water Vulnerability	Sample Size (counties)	Stratum	Sample Allocation (subcounty regions)	Selected Sample Size (subcounty regions)	Sample Allocation (wells)	Selected Sample Size (wells)
High	High	7	Cropped and vulnerable	16	16	24	28
			Remainder of county	36	37	53	63
	Moderate	8	Cropped and vulnerable	24	25	38	42
			Remainder of county	31	32	46	54
	Low	4	Cropped and vulnerable	12	12	18	21
			Remainder of county	16	16	23	27
Moderate	High	5	Cropped and vulnerable	17	18	28	30
			Remainder of county	13	13	18	21
	Moderate	9	Cropped and vulnerable	34	34	50	59
			Remainder of county	9	9	13	16
	Low	4	Cropped and vulnerable	15	15	22	28
			Remainder of county	4	4	6	7
Low	High	8	Cropped and vulnerable	28	29	41	48
			Remainder of county	20	20	30	35
	Moderate	14	Cropped and vulnerable	53	53	76	91
			Remainder of county	14	14	21	24
	Low	7	Cropped and vulnerable	26	27	38	46
			Remainder of county	7	7	10	12

Exhibit B-11 (continued)
Sample Allocation for the Domestic Well Survey

First-Stage Sample			Second-Stage Sample			Third-Stage Sample	
Pesticide Use	Ground-water Vulnerability	Sample Size (counties)	Stratum	Sample Allocation (subcounty regions)	Selected Sample Size (subcounty regions)	Sample Allocation (wells)	Selected Sample Size (wells)
Uncommon	High	7	Cropped and vulnerable	24	25	36	42
			Remainder of county	18	18	26	30
	Moderate	11	Cropped and vulnerable	42	42	61	72
			Remainder of county	11	11	16	19
	Low	6	Cropped and vulnerable	23	23	33	39
			Remainder of county	6	6	9	10
Total	Total	90	Cropped and vulnerable	314	319	463	544
			Remainder of county	185	186	271	319
Total	High	27	Total	172	175	254	298
	Moderate	42	Total	218	220	321	377
	Low	21	Total	109	110	159	188
High	Total	19	Total	135	138	200	235
Moderate	Total	18	Total	92	93	135	160
Low	Total	28	Total	148	149	218	256
Uncommon	Total	25	Total	124	125	181	212
Total	Total	90	Total	499	505	734	863

of three to one relative to the remainder of the county. This rate was a compromise between the desire to maximize the number of samples drawn from wells likely to be contaminated and the absence of knowledge of the location of such wells.

The pilot survey used an area probability sample to select domestic wells within each sampled county. This involved selecting a sample of enumeration districts/block groups (ED/BGs) based on 1980 Census data, sending interviewers into the field to list all housing units in those ED/BGs, selecting a sample of housing units for screening, then returning to the field to screen those housing units for use of well water and finally to conduct the interview and sample the well. ED/BGs in the most cropped and vulnerable parts of each county were oversampled to increase the probability of including contaminated wells in the sample.

The pilot study process was very time consuming. It also relied heavily on local interviewers in each county, since they had to visit the county twice, once to list the housing units and the second time to screen and conduct the interviews.

The sample selection for the main rural domestic well survey therefore was revised, and the sample of housing units was selected through use of random digit dialing (RDD). This procedure requires less time in the field in each county, better controls the sample size, allows for the use of traveling interviewers (taking advantage of improved quality from experienced NPS staff), and spreads the sample more completely throughout the sampled county. The only drawback to using RDD was that households using well water that did not have a telephone were excluded from being selected for the sample. Given the small proportion of households with wells that are without telephones (10 percent). Even with small differences in contamination rates between wells used by households with and without telephones this modification to the target population was not thought to introduce a significant source of bias.

Counties were selected with probabilities proportional to size, where size is defined as the minimum of the number of rural households or number of wells in the county as reported in the 1980 Census. This measure of size is a surrogate for the number of rural wells in the county, which is not provided by the Census. An examination of the first stage weights (the inverse of this probability of selection) for the sampled counties indicates that two of the counties were not selected from the same stratum to which they were assigned. Clarendon County, South Carolina is in stratum 10, but its probability of selection corresponds to the counties selected in stratum 4. Similarly Oakland County, Michigan is in stratum 5, but its probability of selection corresponds to stratum 8. In both cases such a reassignment to a new strata could be the result of revised pesticide use information becoming available after the sample of counties was selected. For the analysis of Survey data, both counties were considered to be in their reassigned strata while retaining their original probability of selection.

The cropped and vulnerable areas of sampled counties were oversampled at a rate of 3:1 relative to the remainder of the county. For design purposes it was assumed that approximately one percent of all wells were contaminated by some analyte. If no oversampling were conducted one would expect a sample of 732 wells to yield only 7 or 8 contaminated wells. This would be too few for use in any relational analyses, one of the two main goals of the NPS. It therefore was important to try and oversample areas of likely contamination. It was not known, however, how strongly being in the "cropped and vulnerable" part of a county would increase the probability that a well contained pesticides. For example, a well without a sanitary seal at the top might become contaminated by water entering the top of the well, regardless of how vulnerable the underlying aquifer was to contamination. Thus it was quite possible that wells not in the cropped and vulnerable parts of a county might be contaminated. If the oversampling rate was too high the resulting weights of contaminated wells could vary significantly. This would have greatly reduced the accuracy of estimates regarding all contaminated wells.

Because the survey is of rural domestic wells, any well in an area defined by the 1980 Census as urban or urbanized was ineligible. The boundaries of such areas did not always correspond with boundaries that were easy to describe. It was sometimes necessary to extend the urban area to the next closest boundary. Thus a few wells that were indeed rural, but located in these "extended urban" areas, had to be excluded from the survey.

A similar situation arose because of boundaries for the oversampled areas. There were actually four categories in which a well could be placed. Actual target areas, extended target, non-target, and undefinable target (too small to describe without including a much larger non-target area). The first two were oversampled while the last two were not. Determination of whether or not to include a well in the "cropped and vulnerable" area for analysis was based on the actual observed location recorded by the field interviewers.

The process of selecting clusters of telephone numbers for the rural areas of sampled counties began with a list of telephone number prefixes and five-digit zip codes. The list indicates which prefixes intersect which zip codes. Before sample selection, the list was examined to see if any zip codes lay entirely within urban areas of the county and if some prefix areas were entirely within these zip codes. Such prefixes were deleted from the set to be sampled.

The maps showing the areas to be oversampled were superimposed on zip code maps to identify the zip codes that intersected the oversampled areas and those that were completely outside the oversampled areas. The latter were classified as nonoversampled prefix areas. The former were mostly mixed prefix areas, that is, areas in which some households with wells were oversampled and others not oversampled.

The sample design called for 734 wells to be sampled from the 90 counties. To account for potential non-response at sample time the RDD screening survey was designed with a goal of 843 completed screening interviews on the assumption of an approximate 15% non-response rate. That is, the size of the screening sample needed to yield (in expectation) 843 eligible wells for sampling.

The RDD process identified clusters of 100 telephone numbers sharing the same six digit telephone number prefix (i.e., the area code and the next three digits). For counties in which all telephone prefixes cover both oversampled ("cropped and vulnerable") and other areas of the county, the size of the screening sample was calculated as:

$$S = n / [rp \{1 + (1 - t) / 3\}]$$

where

n	is the sample size required for the main survey.
r	is the response rate; and
p	is the proportion of households that qualify as rural domestic households and have wells calculated from 1980 decennial census reports;
t	is the proportion of wells in the oversampled part of the county;

For counties in which some telephone prefixes cover only oversampled areas of the county, the size of the screening sample was calculated as:

$$S = n / [rp\,(t+v+(1-t-v) / 3)]$$

where v is the proportion of telephone numbers in prefix areas that cover only non-oversampled areas.

In order to minimize the variance increase associated with RDD clustering, the number of RDD clusters was selected so that, on average, each RDD cluster would contain one rural domestic well. This is achieved by setting the number of RDD clusters equal to the number of wells to be sampled:

$$c = rps(1-2v / 3)$$

However, it was anticipated that there could be distributional problems when the proportion of rural households with wells, p, was small. "Cropped and vulnerable" areas are typically less urban and more likely to have rural domestic wells. To guard against this problem, the number of RDD clusters was increased by 50% in counties with $p < 0.3$. Hence:

$$c = \begin{cases} rps(1-2v / 3) & \text{when } p \geq .3 \\ 1.5\, rps(1-2v / 3) & \text{when } p < .3 \end{cases}$$

Typically, 20 to 25 percent of all 10,000 numbers with the same telephone number prefix (the first six digits, i.e., the area code and the next three digits) are used by residential households. However, residential household numbers tend to be clustered together. Consequently, the RDD process was carried out by identifying clusters of 100 numbers containing some residential numbers. Using this method, the proportion of residential households called can increase to 60% in those clusters.

A cluster of telephone numbers consists of 100 telephone numbers with the same first eight digits (where a telephone number has ten digits in total). The number of telephone numbers needed to identify c RDD clusters of active household numbers was calculated as c divided by the proportion of telephone numbers for residential households in each county. This proportion is 20 to 25 percent nationwide, but varies considerably among counties.

Clusters were then identified by the following procedure. The prefix numbers in each county were arrayed in numerical order. A systematic random sample of clusters, 50 percent greater than the number needed (in order to provide a surplus), was selected. A randomly selected seed number was then selected from each cluster. Each sampled seed telephone number was called and asked if it was a household and was located in the designated county. Clusters whose seed numbers passed both criteria were retained, others were rejected. This procedure continued until c clusters were identified.

A modified version of the Waksberg method was used for sample selection of households within clusters. A constant number of telephone numbers (within the county) per cluster was selected instead of a constant number of households. This produced a sample that was not quite self-weighting, but weights were available and the brief time interval available for the RDD work in a county made the modified method preferable.

The screening interview first asked if the household was in the designated county. Out-of-county households were ineligible. The next question asked if the household was in an urban part of the county. Urban areas were also ineligible. The third geographic question asked if the household was within the boundaries of the oversampled part of the county. If so, the household was retained and became part of the sample. If not, a one-third subsampling rate was applied to select the households to be retained in the final sample.

For some counties it was possible to identify certain telephone prefixes that were only located in zip codes that were entirely in areas which were not cropped and vulnerable. Households with a well in these prefixes were to be subsampled at a rate of 1 in 3. To save time and money the above procedures were slightly modified for such prefixes. Rather than subsampling eligible households, only one-third as many clusters were called from these prefixes. Any eligible respondent in these prefixes was then included in the sample. This retained the same probabilities of selection but required fewer phone calls.

The screening interview also asked whether the household water was obtained from a well. In a few cases households would report that either more than one house shared the same well (but not enough to qualify as a CWS) or that the household used multiple wells for drinking, bathing, or washing. Wells used by multiple households were subsampled in order to achieve equal selection probabilities at the well level. This was done by determining the number of households using the well and then retaining the household with probability of 1 in that number. If a household used more than one well, the well most frequently used was the well included in the survey.

It is also possible for a household to have two (or more) residential phone numbers. In such cases the household was retained with a 1 in 2 probability, which retained an equal probability of selection at the well level.

B4.7 Rural Domestic Well Survey Response Rates

During implementation of the main survey it became clear that the target sample size (indicated in Exhibit B-11) was not going to be met due to a greater non-response rate than anticipated. At the point when 50 counties had been sampled it was estimated that an additional 41 completed samples would be needed to satisfy the design specifications. To account for this 15% non-response rate, an additional sample of 48 wells was added. The increase in sample sizes was two per county in the high pesticide use strata and one per county in other strata.

Because this modification was made relatively early in the Survey implementation, its impact on the final sample weights was minimal. In addition, because of the temporal allocation, the impact of this modification was spread across all strata. There is, however, a small increased (minimal) potential for non-response bias resulting from the greater than expected non-response rate.

The RDD screener for each county lasted three weeks and was allocated temporally in accordance with the field schedule. It started eight weeks prior to the beginning of the two-week sampling period. Three weeks was felt to be the minimum time period necessary for adequate refusal conversion efforts. It was necessary to leave five weeks from when the sample was selected until the field work would commence to allow for time to send out survey materials to selected households, confirm scheduled interviews, and finalize travel schedules. Leaving eight weeks between being selected for the NPS and actually being interviewed/sampled was a potential source of increased nonresponse to the survey.

RDD screener response rates in the telephone center averaged 86.8 percent (nonrespondents being those known households which refused, were contacted the maximum number of times without completing the screener, had language problems, or had other similar problems). This rate was consistently higher in truly rural counties than in those containing large urban populations. There were two reasons for this. First was a difference between urban and rural populations. The second was the fact that when an unexpectedly large number of urban, and therefore ineligible, households were found it was necessary to introduce more telephone numbers into the telephone screening process during the three week period. These numbers therefore did not have available the full three weeks for refusal conversion. They also could not have their attempted contacts spread out over as long a time period. Thus these numbers introduced late in the screening period were less likely to be completed, further reducing the response rate.

For rural domestic wells, a total of 864 eligible wells were selected as part of either the Pilot Survey (for the first six counties) or the telephone screening (for the other 84 counties). Completed water sampling and interviewing was conducted for 752 (87 percent) of these wells. Exhibit B-12 indicates the response rates achieved in each of the five design domains of interest for the rural domestic well survey.

Exhibit B-12
Rural Domestic Well Survey Response Rates

Domain	Eligibles	Respondents	Percent
All Rural Domestic Wells	864	752	87.0
High Ground-water Vulnerability Counties	248	217	87.5
High Pesticide Use Counties	298	264	88.6
High Pesticide Use and Ground-water Vulnerability	99	83	83.8
"Cropped and Vulnerable" County Subregions	413	343	83.1

B5 Temporal Allocation

The pilot study led to improved procedures and techniques in several areas of the Survey. Issues raised by the pilot study were analyzed and presented to the EPA Science Advisory Panel (SAP) in September 1987. One of these issues concerned temporal variation as a factor influencing when and in what concentrations pesticide and nitrate impact drinking water wells, and how to address temporal variation in water sampling.

When the Science Advisory Panel subpanel reviewed the statistical design proposed in the pilot survey they expressed concern that the design should minimize the impact of any temporal (seasonal) variability in pesticide contamination levels. There are many possible reasons for such variability. Among these are: date of pesticide application, variation in ground water levels, rainy seasons versus dry seasons. The impact of all of these is likely to produce complicated patterns of variation in contamination levels. These patterns will also vary from one part of the country to another and from one soil type to another. The SAP therefore urged that rather than trying to explain the temporal variability the NPS should minimize the impact on the results.

The best way to minimize such variability is to spread the samples throughout the year. A second advantage of spreading the sample throughout the year was that this made it possible for the water analyses to be done in a small number of contract laboratories which had limited capacity for analyzing the samples within the 14 days of sampling required by NPS quality assurance protocols. Each well was assigned to a two week time period during which the water samples were to be drawn.

The laboratories' capacities required a ceiling of approximately 40 well samples every two weeks. To satisfy this constraint the samples were allocated across the year-and-a-half data collection period. Since the design domains of interest corresponded to individual and groups of first-stage strata, the most efficient procedure wes to allocate the samples across time separately for each stratum.

In response to the SAP subpanel's recommendations, EPA selected a method of allocating sampling dates to wells across the data collection period randomly within each stratum to minimize the possible impact of temporal bias. The capacities of the analytic laboratories established the ceiling for the number of wells that could be sampled in a particular period. Within this constraint, EPA allocated counties for rural domestic well sampling to two-week time periods spread over an 18-month period, from September 1988 to February 1990. The survey was conducted from April 1988 to August 1988 for the six counties used in the pilot study. Sampling of community water systems was similarly spread out in two-week periods from August 1988 to December 1989.

The initial temporal design was characterized by 28 available two-week time periods (time-slots) and analytic laboratory limitations of 40 samples per time-slot. The initial CWS well sample design specified the 28 time slots from June 1988 to August 6, 1989. The initial rural domestic well sample design specified time-slots beginning August 22, 1988 and ending December 3, 1989.

The distribution of the 599 CWS wells selected for sampling provided just over 20 samples per time slot for the analytic laboratories. Each county selected for sampling in the rural domestic well survey was expected to contribute approximately 9 samples for the analytic laboratories. Thus, in time-slots where CWS well sampling occurred, two counties could be sampled in the same time-slot for the rural domestic well survey, and in other time-slots four counties could be sampled.

The initial temporal allocation of CWS wells is presented in Exhibit B-13. The available time-slots were allocated randomly within strata to the 599 wells selected for sampling. For instance, in the first time-slot one CWS well was sampled from strata 1, 3, 5, and 6; 2 each were sampled from strata 4, 9, and 10; and 3 each were sampled from strata 7, 8, 11, and 12; no wells were sampled in the 2nd stratum in the first time-slot.

The CWS well survey and rural domestic well main survey (i.e., not including the pilot survey) were initially expected to coincide from August 22, 1988 through August 6, 1989, corresponding to CWS time-slots 4 through 28. This corresponds to 25 time-slots for which 2 counties were sampled in the rural domestic well survey. The remaining 34 counties could be sampled at twice the rate, corresponding to 8½ more time-slots (that is, the 34th time-slot would only have approximately 20 samples for the analytic laboratories). The allocation of pairs of counties to the strata is presented in Exhibit B-14. The first 25 pairs were assigned to time-slots coinciding with the CWS temporal allocation. The remaining 17 pairs were sampled at twice the rate (two pairs per time-slot).

The temporal allocation was designed to be random within strata in the sense that, for the CWS well survey, time-slots were randomly allocated within strata to the CWS wells selected for sampling, and for the rural domestic well survey, the 42 "pairs" of counties were randomly allocated within strata to the selected counties. These 42 "pairs" correspond to the 34½ time-slots as indicated above.

The Survey implementation did not manage to adhere exactly to the temporal design, for a variety of reasons. Frequently (114 out of 540 cases) the CWS interviewing/sampling team was not able to comply with the selected sampling period. There were many reasons for this, but most frequently cited was the limitation of travel funds and time available for the NPS, given their regular schedule of activities. The team would frequently request that the sampling period be switched to accommodate its schedule. It was therefore necessary to try and balance the desire to retain the cooperation of State interviewing/sampling teams while minimizing the impact on the temporal sampling design.

Exhibit B-13
Temporal Allocation of CWS Wells

	Time Periods																												Number of Wells
Strata	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	
1	1	1	1	1	1	1	[illegible]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	27
2	[illegible]	1	1	[illegible]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	[illegible]
3	1	[illegible]	1	1	[illegible]	1	1	[illegible]	1	1	[illegible]	1	1	[illegible]	[illegible]	1	[illegible]	[illegible]	1	[illegible]	[illegible]	1	[illegible]	[illegible]	1	[illegible]	[illegible]	1	14
4	[illegible]	[illegible]	1	[illegible]	[illegible]	1	[illegible]	[illegible]	1	1	[illegible]	1	1	[illegible]	[illegible]	1	[illegible]	[illegible]	1	[illegible]	[illegible]	1	[illegible]	[illegible]	1	[illegible]	[illegible]	1	[illegible]
5	1	1	1	1	1	1	1	1	1	[illegible]	1	1	[illegible]	1	1	[illegible]	1	1	[illegible]	1	1	1	1	1	1	1	1	1	[illegible]
6	1	1	1	1	1	1	1	1	1	1	1	1	[illegible]	1	1	[illegible]	1	1	[illegible]	1	1	1	1	1	1	1	1	1	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	71
11	[illegible]	4	[illegible]	[illegible]	4	[illegible]	[illegible]	4	[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	[illegible]	[illegible]	4	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	21	[illegible]	21	21	21	21	21	[illegible]	[illegible]	21	[illegible]	[illegible]	21	21	[illegible]	21	21	[illegible]	21	21	[illegible]	21	21	[illegible]	21	21	[illegible]	[illegible]

Exhibit B-14
Original Allocation of Pairs of Counties to Rural Domestic Well Strata

Strata	Pairs of [illegible] Counties																					Number of Counties
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
1									X					X					X			3
2		X					X					X					X					4
3					X					X												2
4															X					X		2
5			X					X					X					X				4
6	X					X					X											3
7				X												X					X	3
8		X					X		X			X		X			X		X			7
9					X					X					X					X		4
10			X					X														2
11	X					X					X		X			X		X			X	7
12				X																		1
																						42

Exhibit B-14 (continued)
Original Allocation of Pairs of Counties to Rural Domestic Well Strata

Strata	Pairs of [illegible] Counties																					Number of Counties
	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	
1			x					x					x					x				4
2	x					x					x											3
3																x					x	2
4				x					x					x								3
5		x					x					x					x		x			5
6																						0
7					x					x					x					x		4
8	x		x			x		x			x		x					x				7
9																x					x	2
10				x					x					x					x			4
11		x					x					x					x					4
12					x					x					x					x		4
																						42

Two types of time switches were immediately accepted. Any well could be switched to an adjoining two-week period without objection. It was also allowable to switch a sampling date between the same two-week period of 1988 and 1989. Fifty-seven wells moved to adjacent time periods and 14 switched year (5 of these moved a year plus one sampling period).

Many teams requested time changes of more than two weeks (but not one year). The first response was to explain the importance of the temporal design and try to convince the team to retain the scheduled date. When this failed EPA tried to arrange to trade sampling times between two wells in the same stratum and EPA region, thus minimizing the impact on the temporal design. For example, both Alaska wells were assigned sampling periods when the well would be inaccessible due to the cold weather. Their sampling periods were then switched with two wells in the state of Washington which were in the same first-stage stratum. A total of 48 wells were moved more than one two-week period from that originally proposed by the temporal design.

A second temporal issue addressed by the sample design was how to sample seasonal wells. The determination of what procedure to follow depends upon whether one wants to make estimates (e.g. percent of wells contaminated) for all wells *ever* used for drinking, bathing, or showering, or for all wells used on a *typical day*. This can be demonstrated with the following extreme example: assume that there are 730 wells in the country, 365 used year round and 365 each used one day a year. Further assume that the 365 used for only one day are all contaminated while none of the year round wells are contaminated. The survey could be designed to report that half of all wells in the country ever used (365 out of 730) are contaminated; or that less than one percent of all wells in use on a typical day (1 out of 366) are contaminated. It was decided that the less than one percent number would be of more use for policy purposes.

Procedures were developed and implemented to ensure that the probability that a well was included in the survey would be proportional to its frequency of use, and thus provide national estimates for the percentage of wells typically in use. These procedures were different for community system wells and rural domestic wells. For CWS wells they included the following measures: If a system was shut down during the time period the screener was conducted with no one available to answer the phone, the system would have been determined to not be in existence and declared ineligible. If someone was available to answer the phone and could explain the seasonal nature of the system, it was considered eligible for the survey. Actual cases of seasonal wells identified during the survey were extremely rare.

If a sampled community water system was not in use at the selected field sampling time period, it was rescheduled for when it was in use. This is because the population of systems had already been sampled to provide an estimate of all wells in use at a point in time. For domestic wells there was no national screening at a particular point in time. While different counties were assigned sampling intervals throughout the year, a given county was sampled during only one time interval. If a household used well water but the well was not used during the entire two week sampling period (e.g., the well was dry) it was not rescheduled and was considered to be an ineligible well. If a household was on vacation throughout the sampling period the telephone center was unable to reach them and they would therefore not be able to be included in the survey. Thus, as with community water system wells, by including rural domestic wells in proportion to their frequency of use, estimates can be provided for all wells used at any particular time. The actual times of sampling are indicated in Exhibit B-15 (CWS wells), and B-16 (rural domestic wells).

Exhibit B-15

Number of CWS Wells Sampled by Stratum and by Two-Week Periods

	PERIOD																		
	1	2	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Stratum 1	0	0	1	1	1	1	1	2	1	1	1	0	1	1	1	1	0	1	1
Stratum 2	1	0	0	0	1	1	0	1	1	1	1	0	1	1	1	1	1	0	1
Stratum 3	0	0	0	1	2	1	0	1	0	0	0	0	1	0	1	1	0	0	1
Stratum 4	0	0	1	2	2	2	2	3	1	1	1	0	1	1	1	0	1	2	0
Stratum 5	1	0	0	0	1	0	2	3	1	1	1	0	2	1	1	0	0	1	1
Stratum 6	0	0	2	0	1	2	0	1	0	1	1	0	1	0	0	1	1	1	1
Stratum 7	0	0	3	3	3	3	3	3	2	2	1	1	3	2	3	2	2	1	2
Stratum 8	0	1	2	3	4	1	4	2	2	2	2	0	4	1	0	3	2	2	2
Stratum 9	0	0	0	3	3	2	2	1	0	1	1	0	0	1	1	3	2	0	4
Stratum 10	0	0	2	2	3	3	2	1	2	3	1	0	2	3	1	2	2	2	3
Stratum 11	0	0	3	1	4	2	3	2	3	3	3	0	1	3	4	4	5	2	3
Stratum 12	0	0	1	3	4	1	1	2	3	4	1	0	3	2	2	2	1	2	4
Total in Period	2	1	15	19	29	19	20	22	16	20	14	1	20	16	16	20	17	14	23

Exhibit B-15 (continued)

Number of CWS Wells Sampled by Stratum and by Two-Week Periods

	PERIOD																		
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	Total
Stratum 1	0	1	2	1	1	1	0	0	0	0	0	1	0	0	0	0	1	3	37
Stratum 2	1	0	1	1	0	0	0	1	1	1	1	1	3	0	0	0	0	0	24
Stratum 3	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	12
Stratum 4	2	1	4	1	0	0	0	0	1	0	0	2	0	0	2	0	1	3	38
Stratum 5	1	1	1	1	1	1	1	0	0	0	0	1	0	1	1	0	1	0	27
Stratum 6	1	1	1	1	0	0	0	0	1	1	1	0	1	2	0	0	0	0	23
Stratum 7	2	2	3	3	1	1	2	2	1	0	0	2	1	2	3	0	1	2	67
Stratum 8	3	1	1	2	2	1	1	1	1	1	1	2	1	2	2	0	1	0	60
Stratum 9	2	2	3	0	0	1	1	1	1	2	2	1	2	3	2	1	0	0	40
Stratum 10	3	3	2	2	1	1	1	1	1	1	1	3	2	2	2	1	3	0	64
Stratum 11	1	5	3	3	1	0	1	0	2	2	0	5	3	3	6	1	2	0	64
Stratum 12	1	2	1	0	2	2	2	1	0	2	1	2	4	7	2	1	0	0	66
Total In Period	17	19	22	15	10	9	9	8	9	10	7	20	17	22	20	4	10	8	549

Exhibit B-16

Number of Counties Selected for Rural Domestic Well Sampling by Stratum and by Two-Week Period

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Stratum 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Stratum 2	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
Stratum 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Stratum 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stratum 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
Stratum 6	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
Stratum 7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Stratum 8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0
Stratum 9	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Stratum 10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
Stratum 11	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
Stratum 12	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Total in Period	2	0	0	0	1	1	0	2	0	0	0	1	1	1	1	2	2	2	0	2	2	2	3	2

Exhibit B-16 (continued)

Number of Counties Selected for Rural Domestic Well Sampling by Stratum and by Two-Week Period

	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	Total
Stratum 1	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0	1	0	0	7
Stratum 2	0	1	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	8
Stratum 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	4
Stratum 4	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1	0	1	0	0	0	0	0	5
Stratum 5	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	1	0	1	0	0	0	1	0	1	9
Stratum 6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Stratum 7	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	1	1	0	8
Stratum 8	0	1	0	1	0	0	1	0	1	0	0	1	0	1	1	1	0	1	1	0	0	0	1	0	14
Stratum 9	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	7
Stratum 10	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	1	7
Stratum 11	1	0	1	0	0	1	0	1	0	0	1	0	1	0	0	1	0	1	0	0	0	1	0	0	11
Stratum 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	1	0	6
Total in Period	2	2	2	2	2	2	2	2	2	2	2	2	2	4	4	4	4	4	4	0	1	6	3	4	90

B6 Statistical Analysis Procedures

The survey design described in this appendix was implemented during the field sampling and data collection phase of the Survey. Thousands of water samples and large amounts of questionnaire data were collected, analyzed, and sorted into the Survey data base. The following sections deal with the preparation of the Survey data base for analysis, and with the statistical methods used to produce the results contained in Chapter 6 of this report. The statistical topics that are addressed include:

- missing data and imputation;
- weighting; and
- calculation of population estimates and confidence intervals.

This section concludes with a brief comparison of the Survey precision requirements with results of the preliminary statistical analysis of proportions of wells containing detectable levels of at least one pesticide or pesticide degradate.

B6.1 Missing Data and Imputation

The Survey experienced two basic types of missing data: unit non-response (i.e., no data for a sampled well could be recorded); and item non-response (i.e., the data record for a sampled well is missing a few responses, which can pertain either to analytes or questionnaires). Unit non-response is accounted for by a non-response adjustment in the weighting procedures, which are discussed in Section B6.2. Item non-response is accounted for either by data retrieval or imputation, which are discussed in this section.

B6.1.1 Data Retrieval

The initial methods for addressing missing data or inconsistencies in the data include logic checks and data retrieval. A number of logic checks were performed on the Survey data base (see Appendix C for further details). For instance, data on the depth of a well screen could be recoded to be less than or equal to the depth of the well. In some instances, general rules were implemented to make the data more consistent. Data retrieval was attempted for a number of questionnaire items. When these methods for handling missing data could not be used, imputation was performed (for item non-response).

B6.1.2 Hot-Deck Imputation Procedures

Two methods of imputation were used to prepare the Survey database for Phase I data analysis:

- using another item from the same data record; and
- using the same item from a different record.

An example of the first method is the following. If the question "In 1987, were crops farmed within one-half mile of the well?" is unanswered, then the answer to the question "In 1988, were crops farmed within one-half mile of the well?" can be used to infer the missing item. That is, it seems likely that if there was farming this year, then there was probably farming last year.

The second imputation method, using the same item from another record, is applied using hot-deck procedures.[8] Hot-deck procedures were first developed by the U.S. Bureau of the Census.

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[8] Little, R. and Rubin, D. Statistical Analysis with Missing Data, (New York: John Wiley & Sons, 1987)

Hot-deck imputation involves substituting for a missing item of the "recipient" record with the value of the same item of a "donor" record. The donor record and recipient record should be similar. That is, the response to other items should be equal or nearly equal on both the donor and recipient records. For example, suppose an item listing pesticides used on crops is missing. Then the list of pesticides from a donor record is copied to the corresponding missing data item on the recipient record so long as responses to other items are similar. For instance, the effects of these pesticides on well water for the donor and recipient record may be the same only if the first-stage stratum (defining ground water vulnerability and pesticide use) is identical for both the donor and recipient records. Other items should also be similar.

The methodology of hot-deck imputation involves the stratification of the records into cells. This imputation stratification is performed using variables of interest or importance (such as first-stage stratification). For instance, imputation stratification using only the first stage strata would result in 12 stratification cells, where the records within any one cell all have a common first stage stratum. Records within a cell are then sorted according to another item (or items) for which similar values are desired, such as geographic region. In this manner, records that are most similar are adjacent in the list of records within the cell. The record immediately preceding the recipient record is normally selected to be the donor record. It is not selected only if (1) the record immediately preceding the recipient record is also a recipient record; then the next preceding record is considered; (2) no preceding record is available as the donor record; then the first available succeeding record is the donor record; (3) no record is permitted to be a donor record more than twice (thus preventing any single record from dominating results, though domination is unlikely to occur unless a record is a donor record many more times than twice).

Each missing data item could be imputed using both a different imputation stratification into cells and a different sort within cells. Considerable economies can be made, however, if different items have identical imputation strata and sorting variables. The following sections describe the stratification and sorting variables used for items on the analytic results and questionnaires for both the CWS well and rural domestic well surveys.

Imputation for Analyte Data

Many analytes were not detected in any water samples. Hot-decking imputed a value of not detected for such missing items. These analytes are imputed without having to perform stratification and sorting.

For analytes with at least one detection, the imputation strata were, in order:

1. First-stage strata;
2. Responses to the farmed/not farmed indicator (for agricultural chemicals and nitrogen only);
3. "Cropped and vulnerable" area indicator (for the rural domestic well Survey only);
4. An indicator for the use of that analyte within ½ mile of the well; and
5. Crops on which this analyte is used (for agricultural chemicals only).

Within cells the records were sorted by geographic region. For the CWS well survey, the geographic sorting items were EPA Region and State. For the rural domestic well survey, the geographic sorting item was the county.

Often, especially with 5 stratification items for imputation, cells contained very few records and imputation of the records within cells was infeasible. In this case cells were collapsed by dropping out the least important stratification item (i.e., the last stratification item above). If imputation remained infeasible, then the next to last stratification item was dropped, and so on, until all records with missing items were imputed.

Imputation for Questionnaire Data

For missing questionnaire items from the Local Area Questionnaire and the Main Questionnaires for both CWS wells and rural domestic wells, the imputation strata were, in order:

1. First-stage strata;
2. Responses to the farmed/not farmed indicator (Local Area Questionnaires only);
3. The size of the CWS in terms of the number of operating wells (CWS Main Questionnaire, sections A and B only);
4. Crops used within ½ mile of the well (Local Area Questionnaires, and Main Questionnaire, section C only); and
5. Pesticides used within ½ mile of the well (Local Area Questionnaires, and Main Questionnaires, section C only).

Within cells the records were sorted by geographic regions, analogous to those used for the analyte imputation procedure, and collapsing across cells occurred if there were too few items in a cell. Rules for imputing missing CWS data using another item are shown in Exhibits B-17 and B-18. Similar rules apply for the rural domestic well survey.

B6.2 Weighting Procedures

This section describes the weighting procedures that were followed to develop national estimates based on the results from the wells that were sampled by the Survey.

Each well in the CWS and rural domestic well surveys was assigned a weight that corresponds to the number of wells in the population that the well represents. The base weight for a well is the inverse of its probability of selection. The base weights are adjusted for non-response. For the rural domestic well Survey, trimming and post-stratification were used to make further adjustments to the weights.

B6.2.1 Weighting Procedures for the CWS Well Survey

The weighting procedure for the CWS wells consisted of a two-step process. First, a base weight was assigned to each CWS well. Then an adjustment was made to the weights to account for non-response.

CWS Base Weight

The base weight assigned to a well is the inverse of the probability of selection. That probability is the product of three factors associated with each stage of the sample. The CWS well survey was a three-stage design. The first stage consisted of the selection of 6,814 CWSs from the FRDS frame of 50,771 CWSs. The 6,814 CWSs were screened to determine eligibility for sampling (5,660 wells were determined to be eligible) and to determine an estimate of the number of wells in each CWS. The second stage sample consisted of the selection of 666 CWSs from the 5,660 eligible CWSs. The third stage consisted of the selection of one well from each of the 666 CWSs (this is a slight oversimplification of the procedure, since some CWSs were selected more than once at the second stage). The final sample consisted of 592 eligible wells. Analyte and questionnaire data were collected at 540 of these wells.

The first stage weighting factor for a well is the inverse probability of selecting a community water system:

$$W_1 = S_1$$

Exhibit B-17
CWS Main Questionnaire Items Imputed Using Respondent Information

Question No.	Abbreviated Question	Imputation
A.12	What is the distance from the ground surface to the bottom of the casing?	Impute the value recorded in A.5 minus some final value (i.e., 10 feet) since the well is not cased to the total depth.
A.17	What is the total distance from the ground surface to the bottom of the deepest screen?	Impute the value recorded in A.5 (i.e., well depth) if A.11 = 1. If A.11 = 2, then use A.12. If A.11 = 98, then impute 98, "Don't Know."
B.4(a)	In 1988, what non-farm pesticides were stored for more than one month on the property where the well is located?	Impute the series of pesticides for which a positive response was either recorded in question B.4(b) or B.4(c).
B.4(b)	In 1987, what non-farm pesticides were stored for more than one month on the property where the well is located?	Impute the series of pesticides for which a positive response was either recorded in question B.4(a) or B.4(c).
B.4(c)	In 1986, what non-farm pesticides were stored for more than one month on the property where the well is located?	Impute the series of pesticides for which a positive response was either recorded in question B.4(a) or B.4(b).
C.1	Has anyone farmed the property since January 1, 1984?	Impute code 01 "Yes," if a positive response was recorded in either questions C.2 or C.3; otherwise use hot-deck.
C.5(a)	In 1988, what farm pesticides were stored, for more than one month, on the property where the well is located?	Impute the series of pesticides for which a positive response was either recorded in question C.5(b), C.5(c), C.5(d), or C.5(e).
C.5(b)	In 1987, what farm pesticides were stored, for more than one month, on the property where the well is located?	Impute the series of pesticides for which a positive response was either recorded in qeustion C.5(a), C.5(c), C.5(d), or C.5(e).
C.5(c)	In 1986, what farm pesticides were stored, for more than one month, on the property where the well is located?	Impute the series of pesticides for which a positive response was either recorded in question C.5(a), C.5(b), C.5(d), or C.5(e).
C.5(d)	In 1985, what farm pesticides were stored, for more than one mont, on the property where the well is located?	Impute the series of pesticides for which a positive response was either recorded in question C.5(a), C.5(b), C.5(c), or C.5(e).
C.5(e)	In 1984, what farm pesticides were stored, for more than one month, on the property where the well is located?	Impute the series of pesticides for which a positive response was either recorded in question C.5(a), C.5(b), C.5(c), or C.5(d).

Exhibit B-18
Local Area CWS Questionnaire Items Imputed Using Respondent Information

Question No.	Abbreviated Question	Imputation
2a.	In 1988, what crops were farmed and what pesticides were used within one-half mile of the well?	Impute the series of crops and pesticides for which a positive response was first recorded in question 2b or 2c.
2b.	In 1987, what crops were farmed and what pesticides were used within one-half mile of the well?	Impute the series of pesticides for which a positive response was first recorded in question 2a or 2c. Note: Select the responses from only one of the previous years.
2c.	In 1987, what crops were farmed and what pesticides were used within one-half mile of the well?	Impute the series of pesticides for which a positive response was first recorded in question 2a or 2b. Note; Select the responses from only one of the previous years.
4a.	In 1988, what pesticides were used on the pasture?	Impute the series of pesticides for which a positive response was first recorded in question 4b or 4c. Note: Select the responses from only one of the previous years.
4b.	In 1987, what pesticides were used on the pasture?	Impute the series of pesticides for which a positive response was first recorded in question 4a or 4c. Note: Select the responses from only one of the previous years.
4c.	In 1986, what pesticides were used on the pasture?	Impute the series of pesticides for which a positive response was first recorded in question 4a or 4b. Note: Select the responses from only one of the previous years.

where S_1 is the first stage sampling interval within the strata (i.e. on average 1 in every S_1 community water systems was selected). The second stage factor for a well in a community water system is defined as:

$$W_2 = \frac{1}{M_e}\left(\frac{1}{S_2} + \frac{1}{S_2'}\right)^{-1} = \frac{S_2 S_2'}{M_e\,(S_2 + S_2')}$$

where S_2 is the second stage sampling interval within the strata for the original sample, and S_2' is the corresponding sampling interval for the supplemental sample. By using a supplemental sample random start equal to the original random start plus half of the original sampling interval, the chance of a system being selected in both samples was minimized. M_e is the estimated measure of size (estimate of the number of wells in the CWS from the screener survey). If this factor (W_2) is greater than 1 then it is the inverse of the conditional probability of selecting the system (conditional on the first stage CWSs). If this factor is less than 1 then it is the inverse of the conditional expectation of the number of times the CWS is selected in the second stage sample.

For each CWS selected in the second stage the actual number of wells belonging to that system was ascertained at the time of sampling. In eight CWSs, the actual number of wells was found to be much less than the expected number of wells. Instead of selecting multiple wells from these CWSs (as would be required by the second stage sample), only one well was selected. The second stage weight factor for these 8 wells was redefined as $W_2 = 1$.

The third stage factor for a CWS well is the inverse probability of selecting one well from the system,

$$W_3 = M_a$$

where M_a is the actual number of wells in the system (determined at the third stage, i.e., at the time of water sampling). The base weight of a well is then,

$$W_b = W_1 \times W_2 \times W_3.$$

CWS Non-response Adjustment

There were 592 wells in the actual CWS well and analyte sample, and questionnaire data was collected at 540 of these wells. The remaining 52 wells experienced unit non-response. An adjustment to the weights was required to account for those 52 wells. This adjustment was performed by redistributing the unit non-respondent wells among the 540 respondent wells.

The wells are partitioned into cells by stratum and State, and a separate non-response adjustment factor was computed for each cell in this partition. The non-response adjustment factor is,

$$f_1 = \frac{\sum_R W_b + \sum_{NR} W_b}{\sum_R W_b},$$

where $\sum_{R} W_b$ is the sum of the weights of the respondent wells in the cell and $\sum_{NR} W_b$ is the sum of the weights of the nonrespondent wells in the cell. For the few cells in which there were no respondent wells this non-response adjustment factor is defined to be one. A second non-response adjustment factor was then required, since the weights of the nonrespondents in those few cells were not redistributed. In that case the wells were partitioned by stratum and EPA Region. The non-response adjustment factor for cells for this partition is,

$$f_2 = \frac{\sum_{R} (W_b \times f_1) + \sum_{NR} (W_b \times f_1)}{\sum_{R} (W_b \times f_1)},$$

where the summation is over the stratum by EPA Region. There are no cells in this partition without at least one respondent well. The non-response adjustment factor for a well in these cells is the product of the two factors (with different values for wells in different cells),

$$f = f_1 \times f_2.$$

For wells in non-collapsed cells, the non-response adjustment factor is $f = f_1$

Final CWS Weight

The final weight of a well in the CWS well survey was the product of its base weight and its non-response adjustment factor,

$$W = W_b \times f$$

B6.2.2 Rural Domestic Well Weighting Procedures

The weighting procedure for rural domestic wells consisted of a multi-step process. First, a base weight was calculated for each rural domestic well. Calculation of this base weight varied, however, depending on whether the rural domestic well was sampled in one of six pilot study counties or in one of the other 84 counties included in the Survey.

The second stage weights also required an adjustment due to the RDD procedure. A non-response adjustment factor was also required. Finally, a post-stratification adjustment factor was applied due to updated information from the 1987 American Housing Survey administered by the Census Bureau.

Rural Domestic Well Base Weights

The rural domestic well sample is a two stage design. The first stage is a sample of 90 counties in the U.S. The second stage is a sample of rural domestic wells within each county. For the 6 pilot counties, the second stage sample was selected through field interviewing during the pilot study. For the other 84 counties, the second stage sample was selected using random digit dialing (RDD) procedures. The 3,137 counties and county equivalents in the U.S. were stratified into twelve strata (see Exhibit B-2). The 90 first stage counties were then selected within each stratum with probability proportional to size. The measure of size is the minimum of the number of rural households and the number of wells[9]. These numbers are obtained from the 1980 census. The first stage weight for a county is the inverse of the probability of selecting the county, denoted W_1.

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[9] For more details on the first-stage sample selection see RTI's "National Pesticide Survey Pilot Evaluation Technical Report," January 29, 1988.

The sampling rate within each strata was determined using common sampling rates within certain groups of strata; (1) high ground-water vulnerability, (2) high pesticide use, (3) both high vulnerability and high pesticide use, and (4) other strata. After the selection of counties was complete, two of the 90 counties were re-stratified (the 2 counties had been mis-classified with regard to pesticide use). The weights for these 2 counties are unaffected by this re-stratification.

Second Stage Weights for Pilot Counties

The wells selected within the 6 pilot counties were assumed to be a simple random sample. The number of rural wells in the county was assumed to be the minimum of the 1980 Census counts of the number of rural households and the number of wells, denoted N. The second stage weight for a well in the county is the inverse probability of selection specified as:

$$W_2 = \frac{N}{n}$$

where n is the total number of wells selected for sampling in the county.

Second Stage Weights for Other Counties

The wells selected within the 84 other counties were selected using RDD. The RDD survey was implemented using a modification of what is frequently referred to as the Waksberg method.[10] The Waksberg method of RDD draws a sample of households where each household has the same probability of selection. The modified Waksberg method of RDD draws a sample where households may have varying probabilities of selection, although the relative probabilities, and hence relative weights, are known. The purpose of using the modified Waksberg method is that a sample can be obtained more quickly. The Survey identified rural households within a county and assigned weight, denoted W_{RDD}, to each household. The weight for the selection of a household in the county is the inverse probability of selection specified as:

$$W_H = \frac{R}{\sum W_{RDD}} \times W_{RDD}$$

where R is the number of rural households in the county (obtained from the 1980 Census), and ΣW_{RDD} is the total of the weights of the households sampled in the county.

The wells were selected from the households through a series of steps. First, only rural households with wells were retained. Second, all rural households with wells in the "cropped and vulnerable" area of the county were retained, while 1 in 3 of the wells in the "not cropped and vulnerable" area were retained. Third, a sample of wells was drawn from the remaining sample of households with wells (since a well may serve multiple households, a well was retained with probability equal to the inverse of the number of households served by the well). Fourth, a subsample of wells was drawn, since a predetermined number of wells in each county was required for the sample. A weight, denoted W_s, associated with each well in the sample, accounts for this series of steps. The second stage weight for a well in the county is the product of the two weights,

$$W_2 = W_H \times W_s$$

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[10] Waksberg, J. (1978). "Sampling Methods for Random Digit Dialing", Journal of the American Statistical Association, Volume 73, No 361, pp 40-46.

Base Weight Computation

The base weight for a well in the sample is then the product of the first and second-stage weights,

$$W_b = W_1 \times W_2$$

where the second stage weight depends on whether the county is included in the pilot survey or the main survey.

Non-response Adjustment

Each rural domestic well was classed as a respondent or nonrespondent. An adjustment to the weights was required to account for the nonrespondents. The weights of the nonrespondents were redistributed among the weights of the respondents.

The wells were partitioned by stratum and target. The variable target indicates whether the well is in a "cropped and vulnerable" area of the county or not. A non-response adjustment factor was computed for each cell in the partition. The non-response factor is,

$$f = \frac{\sum_{R} W_b + \sum_{NR} W_b}{\sum_{R} W_b}$$

where $\sum_{R} W$ is the sum of the weights of the respondents wells in the cell and $\sum_{NR} W$ is the sum of the weights of the nonrespondent wells in the cell. This is the same adjustment factor as the first factor used in the CWS weight calculations. The adjusted weight of a well is the product of its base weight and non-response adjustment factor,

$$W_a = W_b \times f$$

B6.2.3 Post-Stratification

The 1987 American Housing Survey (AHS) administered by the Census Bureau was used for post-stratification. The 1987 AHS supplies estimates of the number of wells in rural areas by census region and indicates whether or not the wells are on farms. These data update the 1980 Census information and supply more appropriate control totals. There are 4 census regions and farming is classified yes or no according to crop sales. The rural domestic well sample estimates corresponding to these strata (census region and farming) are adjusted to agree with the 1987 AHS. The post-stratification adjustment was computed for each cell of the stratification and is specified as:

$$f_p = \frac{A}{\sum W_a}$$

where A is 1987 AHS estimate of the number of rural wells in the stratification cell, and $\sum W_a$ is the weighted total of the sample wells in the stratification cell.

Final Rural Domestic Well Weight

The final weight of a well is the product of the adjusted weight and post-stratification adjustment,

$$W_f = W_a \times f_p$$

Weight Trimming

After completing post-stratification the distribution of the individual rural domestic well weights was examined to determine if the variability in the weights might produce estimates with exceedingly large mean square errors (MSE). When weights are highly variable it is often possible to reduce the MSE by trimming the largest weights.[11] Trimming will reduce the variability of the weights, but may introduce a source of bias. If this bias is relatively small the net effect of trimming the weights is to reduce the MSE, thereby improving the accuracy of the estimates.

The variability in weights for the rural domestic well survey primarily comes from four sources: sampling error, cluster weights (the probability of selecting a particular cluster of telephone numbers for inclusion in the RDD survey is inversely proportional to the number of households contacted in the cluster), requiring a fixed sample size per county within each stratum (rather than a fixed sampling rate), and relative changes in the number of rural households in a county from the 1980 Census (post-stratification is only able to control the total for a region of the country, not each county). Trimming weights will only introduce bias into the estimates if the reason for the large weights was highly correlated with the variables of interest. Given the above sources of variation in weights, it is doubtful that trimming introduced any significant bias.

The average weight of the 752 rural domestic well respondents was 13,975; with a largest weight of 108,473. The nine wells (1% of the sample) with the largest weights represented 831,000 wells (9% of the population). It was therefore decided to trim these 9 weights that exceeded 60,000 by replacing their weights with 60,000, then re-post-stratifying to retain the national total number of wells. This final component for the rural domestic well weights is incorporated as:

$$W = \min(W_f\,,\ 60{,}000) \times \frac{A}{\sum \min(W_f\,,\ 60{,}000)}$$

This component reallocated a total weight of approximately 270,000 among the wells in the same post-stratification cells as those that were trimmed. Since this represents less than 3 percent of the national total, its impact on any biases is likely to be minimal.

B6.3 Calculation of Population Estimates and Confidence Intervals

The population estimates and confidence intervals presented in Chapter 6 are the result of applying the sample design through the sample weights to appropriate sample statistics. The following sections describe the methods used for calculating the population estimates (in terms of numbers and proportions), and the confidence intervals for those estimates.

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[11] For example, Potter, F., "Survey of Procedures to Control Extreme Sampling Weights," Proceedings of the Section on Survey Research Methods, the American Statistical Association, 1988, pp. 453-458.

B6.3.1 Population Estimates

A population estimate is simply the weighted sum of the sample statistics. Thus, the calculation of population estimates accounts for the complex sample design through the weights. A population estimate, $\hat{X}_d$, (for example, the number of wells in domain d that contain a Survey analyte) is calculated as:

$$\hat{X}_d = \sum_{i=1}^{n_d} W_i X_i$$

where W_i is the weight associated with the $i^{\underline{th}}$ well in the $d^{\underline{th}}$ domain, n_d represents the number of sampled wells in the $d^{\underline{th}}$ domain, and X_i is an indicator for the presence or absence of the analyte.[12] That is, X_i = 0 or 1 where the value of 1 represents presence of the characteristic. The estimate of the proportion, $\hat{P}_d$ is then calculated as

$$\hat{P}_d = \frac{X_d}{N_d}$$

where N_d is the estimated number of wells in the domain population. That is:

$$N_d = \sum_{i=1}^{n_d} W_i$$

hence

$$\hat{P}_d = \frac{\sum_{i=1}^{n_d} W_i X_i}{\sum_{i=1}^{n_d} W_i}$$

Percent estimates are then calculated as $100 \times \hat{P}_d$. (Note that for most domains, N_d is also a random variable, and this affects the calculation of variance estimates as described below.)

B6.3.2 Confidence Intervals

Two methods were used for calculating confidence intervals when the sample estimate is greater than zero in the Survey. Initially, confidence intervals were produced for all characteristics of interest using the WESVAR[13] procedure. The confidence intervals produced in this manner assume an underlying normal distribution for the estimates. Use of the normal distribution is appropriate in the Survey when the binomial parameter of interest is not extreme (i.e., not near zero or one), and the sample size is sufficiently large. Binomial confidence intervals were also calculated for many Survey characteristics when the binomial proportion is very small. Finally, in the most extreme cases, i.e., when the binomial proportion is zero, upper confidence bounds were calculated as described in this section. The three methods are discussed separately below.

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[12] The underlying distribution for these populations is Hypergeometric because the populations are finite, but the populations are large enough that a Binomial distribution assumption (a well either does or does not contain a Survey analyte) is justifiable.

[13] WESVAR is a SAS procedure written and maintained by Westat, Inc.

Confidence Intervals Based on the Normal Distribution

The Survey used a complex design with unequal probabilities of selection for both the CWS and rural domestic well Surveys. This requires the use of complex computation procedures to calculate design-based variance estimates, and hence standard errors and confidence intervals.

Confidence intervals for the Survey were initially calculated using the WESVAR procedure. Briefly, the method used takes a number of subsamples of the actual sample and computes the parameter of interest for each subsample. A variance estimate is then computed as the variance of the values of the parameter estimates from each subsample. These subsamples are usually referred to as replicates. The method is referred to as the Jackknife, or Jackknife replicates, method.[14]

Because of differences in the designs, different approaches to the formation of replicates for the variance estimation were used for the CWS and rural domestic well Surveys. The CWS sample was a systematic sample within each of the 12 first-stage strata with systems as primary sampling units. The variance estimation procedure must reflect this design. Within each of the strata (ground-water vulnerability by pesticide use) the selection order of the wells is known. The wells within a stratum are further partitioned into a number of pairs of variance strata. For instance, the 28 wells in first stage stratum one (high ground-water vulnerability and high pesticide use) are partitioned into 4 variance strata;

variance stratum 1A: 1,3,5,7,9,11,13
variance stratum 1B: 2,4,6,8,10,12,14
variance stratum 2A: 15,17,19,21,23,25,27
variance stratum 2B: 16,18,20,22,24,26,28

where the integers 1 to 28 correspond to the selection order of the wells in the first-stage stratum. The variance strata 1A and 1B form a pair, and the variance strata 2A and 2B forms another pair. Similarly, each of the other 11 first stage strata are partitioned into a number of pairs of variance strata. In this manner, a total of 38 pairs of variance strata (i.e., 76 variance strata) are created. Exhibit B-19 shows the number of variance strata in each of the twelve strata. Variance estimation then employs 38 replicates, where a replicate is formed by selecting one of the 38 pairs of variance strata, deleting the wells from one of the variance strata in that pair, and increasing the weights of the wells in the other variance stratum of the pair.

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[14] Wolter, M. (1985). Introduction to Variance Estimation. Springer-Verlag, New York.

Exhibit B-19
Partition of First Stage Strata Into Variance Strata

First Stage Strata	Number of Wells	Number of Variance Strata	Number of Pairs of Variance Strata
1	28	4	2
2	26	2	1
3	14	2	1
4	39	4	2
5	32	4	2
6	24	4	2
7	71	10	5
8	70	10	5
9	52	6	3
10	75	10	5
11	89	10	5
12	72	10	5
Total	592	76	38

The DWS sample design is a clustered sample within first stage stratum, with 90 counties as the primary sampling units in the first stage sample (see Section B4.4). Thus, 90 replicates are formed, where a replicate is formed by deleting the wells from a county and increasing the weights of the wells in the remaining counties from the same stratum. The jackknife variance estimate thus accounts for the clustered sample within first-stage stratum design.

The variance estimates do not assume an underlying distribution; they are simply variances of a data set. Confidence intervals can be constructed from these variance estimates by making a distributional assumption, such as normality. The form of a 95% confidence interval for an estimate, $\hat{P}$, then is:

$$\hat{P} \pm 1.96\sqrt{VAR(\hat{P})}$$

where $\hat{P}$ is the estimate of the parameter of interest and the value 1.96 corresponds to the 95% confidence interval for the Normal distribution.

Using this method, confidence intervals can be calculated for all parameters of interest in the Survey by assuming an underlying Normal distribution for the parameters, i.e., estimates of population numbers, $\hat{X}$ and population proportions, $\hat{P}$. Recall:

$$\hat{X} = \Sigma W_i X_i$$

and

$$\hat{P} = \frac{\hat{X}}{N} = \frac{\Sigma W_i X_i}{\Sigma W_i}$$

In most domains the population total, N, is also a random variable. (N was assumed fixed in the "rural domestic wells nationally" domain. A value of 10,509,373 was used based on the 1987 American Housing Survey administered by the U.S. Bureau of the Census.) However, variance estimation is performed from the sample data directly. The calculation of variances of ratio estimators is, in some sense, avoided using the

Jackknife replicates method. One effect of the ratio of random variables, however, is that the variance of the proportion does not "match" the variance of the corresponding population number. That is, if N is a constant (as for the "rural domestic wells nationally" domain) then:

$$VAR(\hat{P}) = \frac{1}{N^2} VAR(\hat{X})$$

and the variance of the proportions are a constant multiple of the variance of the numbers. But, when N is a random variable (as is the case for all other domains):

$$VAR(\hat{P}) = \frac{1}{(\hat{N})^2} \left[VAR(\hat{X}) + VAR(\hat{N}) - 2\, COV(\hat{X},\hat{N}) \right]$$

and the respective variances of $\hat{P}$ and $\hat{X}$ are not constant multiples of one another. The jackknife replicates method accounts for this difference implicitly rather than explicitly.

Confidence Intervals Based on the Binomial Distribution

As discussed previously, the underlying distribution of proportions of Survey characteristics is binomial. When the estimated proportion is extreme and the sample size is not large enough to overcome this extremity, the normal distribution approximation to the binomical distribution is not justifiable. For these cases, confidence intervals were based on the Binomial distribution.

The upper bound for the 95% confidence interval for the binomial distribution is calculated by solving for $\hat{P}_u$ in the equation:

$$\sum_{i=0}^{a} \binom{n}{i} \hat{P}_u^{\,i} \left(1 - \hat{P}_u\right)^{n-i} \le 0.025$$

where *n* is the sample size and *a* is the sample estimate of the number of wells for which the characteristic of interest is present. Solving for $\hat{P}_u$ corresponds to computing $\hat{P}_u$ such that for this value the probability of obtaining *a* or less of the characteristic is less than 0.025.

A similar formulation is necessary for the lower bound estimate $\hat{P}_L$:

$$\sum_{i=a}^{n} \binom{n}{i} \hat{P}_L^{\,i} \left(1 - \hat{P}_L\right)^{(n-i)} \le 0.025$$

Pratt and Gibbons[15] (1981) note that the binomial confidence bounds are quantiles of the Beta distribution. The values presented in Chapter 6 were taken from appropriate Beta distribution charts.

In the earlier discussion of confidence intervals based on the normal distribution, the confidence intervals for population estimates did not match those for estimates of proportions (except in the case of rural domestic wells nationally). Unlike proportions, (which follow a binomial distribution), the underlying distribution for population estimates is not clear. Confidence intervals for population estimates corresponding to extreme proportions were calculated by simply adjusting the binomial confidence intervals for proportions to the population size. This makes an implicit assumption that the total number of rural domestic wells (*N*) is a constant, and not a random variable. This method was also used when the sample estimate is zero. Other methods may be used for the Phase II report, which may produce different values.

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[15] Pratt J., and Gibbons J. (1981) Concepts of Nonparametric Theory. Springer-Verlag, New York.

Calculation of confidence intervals reflected the complex sample design, which must be taken into account when computing error bounds. If the Survey had used a simple random sample, then the binomial confidence interval would depend on the sample estimate of the proportion of wells with a particular characteristic of interest (for example, containing detectable levels of an analyte), and the sample size. However, the Survey used a more complex design. The *effective* sample size is calculated for each domain as:

$$n_d' = \frac{n_d}{\delta_d}$$

where n_d is the actual sample size in domain d and δ_d is the design effect.[16] The design effect depends on the weights associated with each well in the domain of interest:

$$\delta_d = \frac{n_d \sum_{i=1}^{n_d} W_i^2}{\left(\sum_{i=1}^{n_d} W_i\right)^2}$$

If the weights are all equal, as is the case with simple random sampling, then the design effect is one. Exhibit B-20 shows the design effects computed for the seven domains of interest in the Survey.

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[16] Kish, L. (1965) Survey Sampling. Wiley, New York.

Exhibit B-20
Design Effects for the Domains of Interest

Domain	Design Effect (δ)	Sample Size (n)	Effective Sample Size (n')
Community water system wells nationally	1.27	540	425
Community water system wells in counties with high vulnerability	1.16	197	170
Rural domestic wells nationally	1.84	752	409
Rural domestic wells in counties with high pesticide use	1.77	217	123
Rural domestic wells in counties with high vulnerability	1.91	264	138
Rural domestic wells in "cropped and vulnerable" regions	2.06	343	167
Rural domestic wells in counties with high pesticide use and high vulnerability	1.44	83	58

In the rural domestic well survey, the design effect also depends on a cluster effect (an effect due to selecting wells in only 90 counties). It is not possible to estimate directly the intra-county correlation for analytes without any detections. Considering analytes that were detected, the intra-county correlation is estimated to be small. The additional factor in the design effect due to the county clustering is therefore negligible, and the design effect in the rural domestic well survey is estimated using the identical formula used for the CWS well survey.

Confidence Bounds When the Sample Estimate is Zero

When the sample estimate, $\hat{p}$, of the proportion of a population characteristic of interest (for example, presence of pesticides above the HAL/MCL in CWS wells) is zero, this does not necessarily imply that the number in the population is also zero. Some percentage of the population may have the characteristic, but the Survey found none by random chance. In these cases an upper confidence bound (95%) is calculated. This confidence bound corresponds to the probability that the Survey does not find the characteristic of interest given the proportion in the population that do have that characteristic. In the case of detectable levels of pesticides above the HAL/MCL in the CWS Survey this can be presented as the probability of no detections in the Survey, given the proportion in the population, *Pr (no detections | p)*. If the Survey used a simple random sample, then each selected well would have a detectable level of the analyte (above HAL/MCL) with probability p, and hence would not have a detectable level above the HAL/MCL with probability $1-p$. Using the binomial distribution assumption, a sample of n wells would then have no detections (above HAL/MCL) if each well was found not to have such a detection. The actual Survey used a complex design, so the weights are accounted for by the design effect as indicated above. Hence:

$$Pr\ (\textit{no detections in domain } d \mid p) = (1 - p)^{n'_d}$$

A 95% upper confidence bound for the proportion in the population, $\hat{p}_d$, is the solution to:

$$(1 - \hat{p}_d)^{n'_d} = 0.05$$

or equivalently,

$$\hat{p}_d = 1 - 0.05^{1/n'_d}$$

The calculations for the 95% upper confidence bounds also account for non-response. These upper bound estimates were initially required for analytes that were not detected in the Survey. For example, pebulate was not detected in the Survey, but, for the reasons outlined above, this does not mean that pebulate is not present in any CWS wells or rural domestic wells nationwide.

The design effects were calculated based on the complete sample within domains. However, the initial sample size used for these binomial upper confidence bounds corresponds to the number of respondent wells. This value differs for each analyte. The most conservative upper bounds correspond to the analyte that has greatest non-response. That is, a different upper bound exists for each analyte. The one presented here corresponds to the analyte with the greatest non-response and hence the smallest initial sample size. Exhibit B-21 presents the actual sample sizes, effective sample sizes, and 95% upper confidence bounds for the seven domains of interest. The exhibit also includes the name of the analyte that had greatest non-response in each domain.

Exhibit B-21
Confidence Bounds for Population Estimates of Zero

Domain	Sample Size	Effective Sample Size	95% Upper Confidence Bound	Analyte Used
Community water system wells nationally	479	377	.008	Pebulate
Community water system wells in counties with high vulnerability	168	145	.020	Pebulate
Rural domestic wells nationally	694	377	.008	Butachlor
Rural domestic wells in counties with high pesticide use	192	108	.027	Ametryn
Rural domestic wells in counties with high vulnerability	236	124	.024	Butachlor
Rural domestic wells in "cropped and vulnerable" regions	305	148	.020	Butachlor
Rural domestic wells in counties with high pesticide use and high vulnerability	66	46	.063	Butachlor

The estimates presented in Exhibit B-21 were presented in Chapter 6 whenever a population estimate was zero (or, the sample estimate was zero). A separate calculation should be made in each case to account for non-response for each particular characteristic of interest. The estimates used are conservative for all analytes as described above. Calculation of more accurate upper bounds for each individual case would have been time consuming and would not have resulted in substantially different estimates.

Geometric Means and Confidence Intervals

Geometric means, with confidence intervals, are provided in Chapter 6 for nitrate, atrazine, and DCPA acid metabolites, separately for both CWS wells and rural domestic wells. This section explains how they are calculated.

The geometric mean, GM, of a set of positive numbers $(x_1, x_2, \ldots x_n)$ is defined as:

$$GM = \exp\left\{\frac{1}{n}\sum_{i=1}^{n} \log_e x_i\right\}$$

This formulation makes no distributional assumptions and may be regarded as a summary statistic. As the data in the NPS is weighted, a weighted geometric mean, GM_w, is a more appropriate summary statistic and is the one presented in Chapter 6:

$$GM_w = \exp\left\{\frac{1}{N}\sum_{i=1}^{n} W_i \log_e x_i\right\}$$

where N is the population size, or more generally, $N = \sum_{i=1}^{n} W_i$; and W_i represents the weight of a particular observation.

To obtain confidence intervals for the geometric mean requires distributional assumptions. The most usual assumptions (for unweighted data) are that the natural logarithm transformation for the data follows a normal distribution, so that the data follows a lognormal distribution. A sample estimate of the mean of Y is:

$$\hat{\mu} = \frac{1}{n}\sum Y_i = \frac{1}{n}\sum \log_e x_i$$

The sample geometric mean can then be calculated as $e^{\hat{\mu}}$. Confidence intervals at 95% for the mean of log transformed data can also be calculated as

$$\hat{\mu} \pm 1.96\,\hat{\sigma} / \sqrt{n}$$

where $\hat{\sigma}$ is the usual estimator of the standard deviation for normal data $\left(\hat{\sigma}^2 = \frac{1}{n-1}\sum (y_i - \bar{y})^2\right)$. Confidence intervals for the geometric mean of sample data can then be calculated by taking exponents of the limits of the confidence interval for μ. This procedure provides confidence intervals for the geometric mean in the sense that the NPS data is weighted to account for the Survey design, and a weighted geometric mean is appropriate. Accordingly, confidence intervals for μ were calculated using the WESVAR procedure.

If the geometric mean and confidence bounds are denoted e^{μ}, e^{μ_L}, *and* e^{μ_U} then the geometric standard deviation (GSD) can be calculated as follows:

$$\mu_L = \mu - 1.96\,\sigma / \sqrt{n}$$

hence

$$\sigma = \frac{(\mu - \mu_L)\sqrt{n}}{1.96}$$

The geometric standard deviation is the exponential of this result, e^{σ}. The sample size used in this calculation should account for the design through the design effect (see Exhibit B-20). The geometric standard deviation is not the standard deviation of the lognormal distribution.

The NPS concentration data is truncated at the lower end by the MRL associated with each chemical. Consequently, the geometric mean, which is an estimate for the NPS data only, and the confidence intervals, which relied on an assumption of normality for the log transformed data, should be regarded as preliminary. Concentration distributions will be estimated in Phase II.

B6.4 Comparison of Phase I Results With Precision Requirements

The precision requirements for the Survey are presented in Exhibits B-5 (for the CWS well survey) and B-10 (for the rural domestic well survey). Exhibit B-22 provides a comparison of the precision requirements in terms of relative standard errors and detection probabilities, and the corresponding values achieved by the Survey for the proportions of wells with detectable levels of at least one pesticide for each of the seven domains of interest. Necessary formulas are provided in Section B3.1.

For comparison purposes, relative domain sizes are provided though the relative standard errors and detection probabilities are calculated based on assumed (for the precision requirements) and estimated (from the Survey data) detection rates within each domain. That is, the assumed $\hat{P}$ for the precision requirements is 0.5% for both CWS domains, and 1% for all rural domestic well domains, and the estimated $\hat{P}$ for the values achieved by the Survey are (in order) 10.41%, 9.30%, 4.24%, 3.55%, 2.77%, 5.48%, and 1.41% (as shown in Chapter 6 of the Phase I Report). The difference between these values and the relative domain sizes is accounted for by the assumed and estimated domain population sizes. For example, of the estimated 94,600 CWS wells nationally, 20,800 were in counties with high ground-water vulnerability.

As can be seen (Exhibit B-22), the Survey surpassed the design specified precision requirements. The actual relative standard errors are all lower, and, consequently, the actual detection probabilities are all higher. The reasons for this are twofold. The specified precision specifications were purposefully conservative and the proportions of wells that contain detectable levels of at least one pesticide was greater than expected, especially for the CWS well survey.

Exhibit B-22
Comparison of Survey Design Precision Requirements With Survey Results

	Design Specifications			Survey Results		
	Relative Domain Size	RSE	Detection Probability	Domain Size	RSE	Detection Probability
Community water system wells nationally	0.5%	0.658	0.80	10.81%	0.14	1.00
Community water system wells in counties with high vulnerability	0.1%	1.040	0.60	2.16%	0.24	1.00
Rural domestic wells nationally	1.0%	1.0	0.63	4.24%	0.23	1.00
Rural domestic wells in counties with high pesticide use	0.14%	0.85	0.75	0.39%	0.47	0.99
Rural domestic wells in counties with high vulnerability	0.25%	0.85	0.75	0.70%	0.50	0.98
Rural domestic wells in "cropped and vulnerable" regions	0.25%	0.525	0.97	1.93%	0.32	1.00
Rural domestic wells in counties with high pesticide use and high vulnerability	0.03%	1.25	0.47	0.05%	1.10	0.56

National Pesticide Survey

Appendix C: Implementation of the Survey

Appendix C: Implementation of the Survey

C1 Introduction

This Appendix describes the activities that occurred between January 1988 and February 1990, in order to carry out well sampling and data collection for the National Pesticide Survey. The activities that formed the core of NPS implementation include training of field sampling and interviewing teams, selecting eligible wells, field operations and data collection, and database development. They are described below in roughly the chronological order in which they were carried out.

C2 Training of Field Sampling/Interviewing Teams

The National Pesticide Survey (NPS) Well Sampling Training Program provided NPS samplers with technical training in sampling and interviewing procedures to ensure the consistency and integrity of the data collected during the Survey. All EPA Regional participants and State personnel conducting well sampling or administering questionnaires received the NPS CWS Training Program. For the rural domestic well survey, separate training sessions were held for samplers and interviewers. Participants received formal personal instruction from NPS staff for specific procedures and were given written training materials, including the CWS or Rural Domestic Well Training Manuals.[1] NPS training of EPA Regional and State sampling teams was presented in one-day or one-and-a-half day workshops (depending on schedules and travel budgets of State or Regional personnel) by CWS trainers. The NPS prime contractor, ICF Incorporated, conducted rural domestic well sampling training at its headquarters and regional offices and observed at scheduled sampling sites to provide hands-on field sampling training to staff. For the rural domestic well survey, interviewers from the NPS survey subcontractor, Westat Incorporated, received a minimum of four hours of general interviewer training and nine hours of NPS-specific training, covering both interviewing and assisting with water sampling. These training sessions were conducted at Westat's headquarters. All well sampling teams received training manuals providing guidance on field team organization, well area data collection, sampling of wells, and administration of questionnaires. The Field Logbook provided detailed guidelines, checklists, and forms for NPS team members to conduct their work. NPS sampling team trainers conducted training for contractor, State and Regional staff from May 1988 to June 1989.

C2.1 Training Topics and Materials

The NPS CWS training covered the following topics:

- An overview of the NPS;
- Field team organization;
- Well area data collection;
- General instructions for sampling CWS wells;
- Field well site water sampling procedures;
- Instructions for administering CWS well questionnaires;
- Chlorine test procedures; and
- Communications.

NPS rural domestic well training was split into two parts. Water samplers were trained on the sampling procedures; interviewers were trained in interviewing and water sampling assistance.

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[1] Water sample collection training procedures for Community Water System (CWS) wells and rural domestic wells were similar. When the training varied, the differences are described.

The NPS Well Sampling and Interviewing Training Overview. The NPS well sampling and interviewing training began with an overview of the goals and objectives of the NPS and an explanation of the background, history, and need for the Survey. The trainer also outlined the key elements of the four major components of the Survey:

1. Selecting a representative set of drinking water wells (NPS statistical sampling design);
2. Collecting and analyzing well water samples to measure the types and amounts of pesticides present;
3. Issuing Health Advisories to well owners/residents[2] with sampled wells containing levels of pesticide or nitrate concentrations that may pose a health risk; and
4. Collecting key information through questionnaires and forms to obtain data on additional factors affecting the presence of pesticides or nitrate in drinking water wells.

Training in Field Team Organization and Responsibilities. This training section emphasized the organization and assignment of field duties, logistical arrangements, and the practice of field procedures. Field sampling teams learned the duties of the three individuals on each sampling team: the field team leader, well sample collector, and questionnaire interviewer. (For many CWS and rural domestic wells, these three roles were handled by two people.) The field team leader received instructions for overall coordination of sampling (and data collection for CWS wells) activities such as preparation, mobilization, sampling, interviewing (for CWS wells), shipment of sample container kits to the laboratories, and return of the field equipment after completion of all well assignments. The field team leader also learned to monitor all activities (sampling only for rural domestic wells) to uphold quality assurance protocols. The well sample collector learned all appropriate procedures to ensure proper sampling techniques in the field. The designated questionnaire interviewer learned to schedule interviews with local officials, review and prepare questionnaires prior to field visits, conduct interviews, edit each questionnaire upon completion, and return all completed questionnaires and other interviewing materials to the appropriate NPS staff (the field team leader for CWS and the field supervisor for rural domestic well sampling).

Training in Well Area Data Collection. The complexity of prefield preparation and sampling of well sites required extensive hands-on training and supporting written documents to ensure consistency during the Survey. NPS staff responsible for collecting data on the well area were trained to use the NPS Field Logbook, the main instrument for recordkeeping during well sampling. The Field Logbook contained forms, checklists, and instructions for sampling (and data collection for CWS wells). Exhibit C-1 provides a list of all training materials provided in the Field Logbook as well as other supporting materials.

Training for Sampling Wells. The field sampling teams received instructions for collecting well water samples. Participants learned about health and safety aspects of sampling, quality assurance/quality control procedures, and communications protocols with well owners, county officials, and the news media.

Health and Safety. This training emphasized the safe handling of sample preservatives such as mercuric chloride, sulfuric acid, and pH buffer solution. The sampling teams received a copy of the Materials Safety Data Sheets for each preservative.

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[2] The term "owners/residents" is used to encompass the public or private use of both CWS and domestic wells. CWS wells belong to a public water system that can involve several "residents." Domestic wells are privately owned wells used by the "owner" or by "residents" who rent the property from the owner.

Exhibit C-1
Training Materials for the Well Sampling Training Program[3]

Field Logbook Materials

- Well Sampling Information Sheet;
- Instructions for use of the Field Logbook;
- Supply Kit Equipment Checklist;
- CWS/Rural Domestic Well Purging Parameters Record;
- Final CWS/Rural Domestic Well Checklist;
- Shipping Confirmation Sheet;
- Team Leader Introduction and Well Observation Record Booklet;
- Field Well Site Water Sampling Manual; and
- Interviewing Package including a CWS Questionnaire and a Local Area CWS Questionnaire.

Other Supporting Materials

- Instructions for the Conductivity Tester;
- Instructions for the pH Tester;
- Instructions for the Temperature Tester;
- Materials Safety Data Sheets; and
- Federal Express Airbill.

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[3] These materials are contained in the NPS Field Logbook and the appendices to the CWS Training Manual and the Domestic Well Manual.

Quality Assurance/Quality Control. This training stressed the need to crosscheck other team members' work (for rural domestic wells such crosschecking was limited to water sampling activities). Completion of collection forms, bottle labeling, and packaging were covered; sampling team members were taught to use the NPS hotline for consultation about sampling problems. Sampling team members were trained to review and edit questionnaires in the field, to ensure that they were complete and legible. CWS sampling team members were also asked to contact the CWS field director, via the NPS hotline, with questions about completing the questionnaires. Rural domestic well interviewers were trained to contact the rural domestic well field director directly.

Communications. This training taught field team members how to answer technical questions about the NPS, and to inform the questioner about other sources of information, especially the toll-free NPS hotline.

Training in Field Well Site Sampling Procedures. Each field team member received training in conducting well sampling that included prefield preparation, CWS/rural domestic well sampling procedures, and procedures to follow after completion of sample collection. The training also discussed the rationale for technical procedures during sampling, such as the use of different sized sample bottles to accommodate various analytic procedures at the contract laboratories. (Section C4.3 provides a description of sampling procedures.)

Prefield Preparation. Field team members learned the detailed steps in the Well Sampling Information Sheet and the Team Leader Introduction and Well Observation Record contained in the Field Logbook.

CWS/Rural Domestic Well Sampling Procedures. The training for sampling procedures included explanations of how to:

- Randomly select one well site among all wells comprising the water system (CWS only);
- Locate a sampling port or tap as close to the well head as possible;
- Measure the air temperature around the well tap;
- Open the well sampling port or tap valve and purge the well (measure pH, temperature, and conductivity);
- Collect a sample of water;
- Properly handle and label sample bottles;
- Review and complete relevant paperwork on the Sample Tracking Form to check that all sample bottles were collected in the sample container kit; and
- Conduct the final pH, conductivity, and temperature measurements, and appropriately mark the readings on the CWS/Rural Domestic Well Purging Parameters Record.

After Sample Collection. Field team members learned that shipping the samples according to procedures was essential to preserve the integrity of the samples. NPS field sampling teams learned how to pack sample container kits in ice, properly complete the Federal Express Airbill, complete the Well Observation Record, and ship the samples to laboratories.

Training for Administering CWS/Rural Domestic Well Questionnaires. Designated interviewers learned how to administer Main and Local Area questionnaires. The topics covered included:

> **General Interviewing Techniques.** Participants learned how to obtain the cooperation of the respondent, ask questions in an unbiased manner, and record the data so that it could be easily transferred to a computerized data base.
>
> **Technical Information.** The trainer reviewed each question in the questionnaires, giving the intent of the question, providing the interviewer with written definitions of technical terms to be read to the respondent in answer to his or her questions, and teaching the interviewer how to record the response. Rural domestic well training included role playing to practice handling different potential situations.
>
> **Answers to Respondents' Questions.** Participants were provided with a list of answers to questions commonly raised by respondents during interviews concerning the objectives of the Survey and how they would be notified about the results of their water samples.

Training in Chlorine Test Procedures. During the Survey, NPS contract laboratories discovered free chlorine in some well water samples that had been collected before treatment of the water supply. Therefore, sampling teams received additional instructions through letters and phone calls on how to resolve this problem and received new test procedures in the chlorine test kit enclosed in the equipment supply kit. There was a slight variation between chlorine testing for CWS and rural domestic wells, but both procedures still assured accuracy and consistency of sample results. CWS sampling teams learned how to conduct a simpler qualitative chlorine test procedure; rural domestic well sampling teams received training to implement a more complex quantitative chlorine determination procedure.

Training in Communications and Confidentiality Issues (rural domestic well training only). Rural domestic well sampling teams received special training to address confidentiality issues for the owners/residents of sampled rural domestic wells. EPA established a confidentiality policy to protect the privacy of rural domestic well participants because of the potentially sensitive nature of the sampling and data information. The policy does not apply to community water systems since these systems serve the public and therefore any CWS data is considered public information. Field sampling teams learned to communicate EPA's confidentiality policy to rural domestic well participants and assure them that sample results would only be released to the State and EPA. No questionnaire information would be made available to anyone unless stripped of all identifiers. Where States had a more stringent confidentiality policy or a conflicting policy, this information was provided to the field sampling teams in their communications packets and explained to participants when inquiries were made.

C2.2 Scheduling CWS and Rural Domestic Well Sampling Training

Dozens of CWS and rural domestic well sampling teams required training in specific NPS sampling and data collection procedures. The State and Regional CWS sampling teams were located in 49 States and the NPS training group manager had to ensure that each team was prepared to conduct well sampling and data collection activities prior to their first scheduled NPS assignment. It was also desirable to schedule each CWS training workshop as close as practical to the date of the first sampling assignment for those being trained to maximize the value of instruction.

Scheduling CWS Training

EPA Regional and State NPS sampling teams were selected by EPA Regional and State contacts. Once all CWS sampling dates were scheduled and sampling teams were identified in a given State, the NPS communications manager notified the State CWS Sampling Contact to select a date and location for NPS CWS training. The NPS CWS training program was presented in a one-and-a-half day workshop; however, if participants' schedules or travel budgets could not accommodate an overnight stay, the workshop was condensed into a one-day session. To the extent feasible, training programs were scheduled close to the sampling team's first scheduled sampling assignment. If possible, the training was scheduled to allow the trainers to accompany the State or Regional sampling team on their first sampling assignment to provide them with hands-on field training. In large States, multiple CWS training programs were scheduled to accommodate sampling teams located in different regions within the State.

The NPS communications coordinator arranged logistics for the training session, including locating a training facility, obtaining directions to the training site, and providing the State Sampling Contact, in writing, with this information. Training manuals were shipped to the training location prior to the scheduled training date to provide participants an opportunity to review the materials.

The NPS training group manager assigned a CWS well sampling trainer for each training program. The NPS provided instructors for interviewer training. The interviewing instructors underwent a training program themselves which included a trainer's manual and monitoring by another trainer during their first training session. This was done to ensure consistent quality for all training sessions. The NPS communications coordinator prepared a monthly training schedule for all CWS trainers and provided them with logistical information for each program.

Scheduling Rural Domestic Well Training

NPS contractor staff were independently trained in rural domestic wellwater sampling and interviewing procedures. The interviewing trainers instructed rural domestic well interviewers on survey administration protocols and procedures for assisting with water sampling prior to the implementation of NPS rural domestic wellwater field sampling. The NPS training group manager selected dates for NPS rural domestic well sampling training for field office sampling teams. To the extent possible, water sampling training programs were scheduled close to the sampling team's first scheduled sampling assignment. If possible, the training was scheduled to allow the trainers to accompany the well sampling team on their first scheduled sampling assignment to provide them with hands-on field sampling training.

The rural domestic wellwater sampling teams were trained in the prime contractor's regional offices, where sampling team members were located. The NPS training group manager coordinated with the NPS field office manager to schedule the training and make necessary logistical arrangements. The NPS field office manager was responsible for informing the field office sampling team of the training dates and location and verifying with the NPS training group manager the number of participants expected to attend the training program in that region. Training manuals were shipped to the training locations prior to the scheduled training dates. Before the rural domestic well sampling training was conducted in a region, each NPS field office manager assigned the field sampling team to specific county assignments and informed the NPS well sampling group manager of these assignments.

The NPS training group manager assigned a rural domestic well trainer to each training program. The NPS training group manager prepared a monthly training schedule for all rural domestic well sampling trainers and provided them with logistical information for each program.

The rural domestic well survey field interviewers were trained at the subcontractor's headquarters in Rockville, Maryland. Three rural domestic well survey field interviewing training sessions were conducted during the course of the Survey. Training sessions were scheduled as new interviewers were required to meet the Survey schedule.

Scheduling CWS and Rural Domestic Well Refresher Training

NPS sampling training workshops were held from May 1988 until June 1989. If an extended period of time lapsed between the first sampling assignment and subsequent sampling assignments, the NPS training group manager contacted the sampling team by phone to review sampling protocols prior to the next sampling assignment. The NPS training group manager provided refresher training instruction to CWS and rural domestic well sampling teams until January 1990. (After training was completed in Minnesota, the Minnesota sampling teams requested that District Engineers be allowed to conduct the interviews with CWS owners/operators. The District Engineers were trained to complete the questionnaires by the CWS field director over the telephone.)

In addition, steps were taken to identify and retrain team interviewers. These steps are described in detail in Section C4.4 under field supervision.

C3 Selecting Eligible Wells

C3.1 CWS

Procedures for Scheduling Community Well Field Sampling

From July 1988 through December 1989, EPA sampled 566 Community Water System (CWS) wells in 49 states. EPA had to identify a representative sample of CWS that met specific NPS eligibility criteria prior to collecting drinking water samples. EPA developed a master CWS sampling schedule and conveyed this schedule to State and Regional CWS Contacts and CWS owners/operators. The Sampling Team contacted the CWS owner/operator to arrange a convenient field sampling date. The NPS implementation support subcontractor screened the frame, selected the sample, and provided the first draft of the project schedule. The NPS prime implementation support contractor facilitated the final scheduling activities.

Screening to Identify Eligible Community Wells

EPA initiated screening to identify eligible community wells with the 1984 Federal Reporting Data System (FRDS). A community water system was defined in the NPS study as a water distribution system that:

- Provides piped drinking water;
- Has 15 or more connections; and/or
- Provides water to 25 or more people who are permanent residents of the service area.

The Federal Reporting Data System (FRDS) was selected as an initial sample frame to identify the population of community water systems. Using the definitions listed above, over 51,000 entries in the FRDS were identified as possible eligible CWS. Of these 51,000 entities, 7,083 were randomly selected for continued consideration for eligibility.

Each EPA Region was sent a copy of the list of CWS in its Region that were selected to be in the sample of 7,083 systems. The Regions then sent this information to each individual State for review. Comments and corrections were returned by States and Regions and integrated into the FRDS sub-sample. The experience with the State of California illustrates the value of this methodology. Upon reviewing the sample selected for California, the State determined that the FRDS file used as the sampling frame was missing all small community water systems in the State. (California had provided the submission to FRDS, but only after the NPS sampling frame had been extracted.) California provided EPA with an updated frame for the State and a revised CWS sample was selected in California.

The resulting sample of systems with corrections provided by the States and Regions, was forwarded to the next eligibility determination phase, the telephone administration of the "CWS Screener" questionnaire. The CWS Screener contained twenty questions and took approximately five to ten minutes to administer. The CWS Screener was administered by telephone interviewers to a representative of each CWS. The screener helped to:

- Verify that each entry was a CWS with at least one working drinking water well;
- Determine the number of working drinking water wells at each CWS;
- Identify the entries in the sample that represented multiple CWS; and
- Identify a contact person at each CWS to aid in the collection of additional questionnaire data and water samples.

Based on the responses to the screening questionnaire, it was possible to determine whether the CWS was eligible for inclusion in the follow-up Survey. Based on probability sampling procedures (described in Appendix B), 599 CWS wells were selected from eligible systems for administration of the CWS Questionnaires and well water sampling.[4]

The sample of Community Water Systems obtained from the FRDS presented considerable location problems. It was found that 13.4 percent of all cases would require extensive tracing. (Tracing refers to the steps and procedures followed to locate the well owner/operator and the information being collected.) Specifically, the telephone interviewers called one or more of the following places to locate a CWS:

- City Hall and Town Clerk
- Local or County Health Department
- Local or County Environmental Resources
- Post Office
- Rural Mail Carriers
- Libraries
- Local Water and Utilities Department
- Public Works
- Tax Assessor
- Planning Commission
- Chamber of Commerce
- Housing Development Authority
- Real Estate Agents
- Police Departments
- Fire Stations
- Small Community Liquor Stores
- Community Centers
- Gas Stations

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[4] The CWS sample comprised all States except Kentucky. At the request of the State of Kentucky, EPA sampled Kentucky CWS wells but excluded these well sample results from the Survey findings so as to not compromise the sample design.

The tracing effort resulted in successfully locating 85.7 percent of all initial tracing cases. The final screening success rate was 96.9 percent, with only 2.6 percent of the total sample not located.

Once the CWS Screeners were completed, the CWS site identification number and the total number of wells per site were entered into a computer data base file. After all completed cases were entered in the file, random sampling procedures were initiated that resulted in 599 CWS being selected for the sample of wells to be tested and surveyed. The contact information (well owner's name, address, phone number) was then entered for the 599 CWS in the file.

Each eligible system selected was allocated a two-week sampling window. This effort resulted in the master CWS sampling schedule.

Communicating With CWS Contacts and CWS Owner/Operator

EPA distributed the master CWS sampling schedule to EPA Regional and State contacts in June 1988, requesting that the contacts indicate a preferred sampling week within the two-week window identified. State contacts then sent a letter to each CWS owner/operator indicating that their system was selected for sampling as part of the National Pesticide Survey. The letter stated they would be contacted by a CWS Sampling Team member to confirm an exact sampling appointment.

Scheduling Field Sampling Dates

The NPS State or Regional sampler responsible for each CWS was contacted to finalize the actual sampling date and ensure that the necessary sampling equipment was sent on time. The sampler was responsible for telephoning the CWS owner/operator to arrange a convenient date and relaying this information to the scheduler. In addition to scheduling a sampling and interviewing visit, the CWS sampler also had to arrange an interview with the local area expert (usually the county agricultural extension agent) to discuss local farming practices, and pesticide use.

In some instances during the scheduling procedure, the CWS sampler discovered that the system no longer met NPS criteria. For example, the system might have closed down since the initial screening call was placed, or the CWS design did not permit sampling prior to treatment. This information was always confirmed and then entered into the NPS Information System (NPSIS). NPSIS is described in detail in Section C4.7.

Finalizing Field Sampling Dates

The CWS Field Sampling Logbook was sent to the sampler approximately eight weeks prior to the preferred sampling week. (The Logbook contained the name, address, and phone number of the CWS owner/operator and a script for telephoning the individual to schedule a sampling appointment.) After the samplers contacted the owner/operator, and confirmed an exact sampling date, the sampling date was entered into NPSIS. When CWS confirmation dates fell outside of the two week sampling period, statisticians determined whether the deviation was permissible based on the temporal sampling guidelines (see Appendix B). Any unallowable deviations were resolved by contacting the samplers to reschedule a more acceptable date. All deviations were recorded in the Tracking System to be used during the analysis phase.

CWS with unconfirmed dates were coded in the NPSIS communications data base to track outstanding sampling dates, and a report was generated for daily review. A copy of the NPSIS summary report of scheduled sampling dates for one State is provided in Exhibit C-2. Four weeks prior to the preferred sampling date, the contractor conducted a "gentle reminder call" to samplers included in the unconfirmed CWS schedule report. Two weeks prior to the sampling period, sampling kits and supplies were shipped to the sampler. All well schedules were usually confirmed by this time.

Exhibit C-2
Scheduled Sampling Dates

Community Well Systems	Stratum	Number of Wells in System	Week for Sampling Confirmed With CWS	Sampling Time Frame	
				Potential Sampling Week 1	Potential Sampling Week 2
CWS 1	4	2	10/17/88 - 10/21/88	10/17/88 - 10/21/88	10/24/88 - 10/28/88
CWS 2	11	3	12/12/88 - 12/16/88	12/12/88 - 12/16/88	01/02/89 - 01/06/89
CWS 3*	12	40	01/09/89 01/13/89	01/09/89 - 01/13/89	01/16/89 - 01/20/89
CWS 4	8	2	01/09/89 - 01/13/89	01/09/89 - 01/13/89	01/16/89 - 01/20/89
CWS 5	7	2	02/20/89 - 02/24/89	02/20/89 - 02/24/89	02/27/89 - 03/03/89
CWS 6	4	3	03/06/89 - 03/10/89	03/06/89 - 03/10/89	03/13/89 - 03/17/89
CWS 7	11	1	03/20/89 - 03/24/89	03/20/89 - 03/24/89	03/27/89 - 03/31/89
CWS 8	12	2	04/17/89 - 04/21/89	04/17/89 - 04/21/89	04/24/89 - 04/28/89
CWS 9	11	12	05/01/89 - 05/05/89	05/01/89 - 05/05/89	05/08/89 - 05/12/89
CWS 10	7	20	05/01/89 - 05/05/89	05/01/89 - 05/05/89	05/08/89 - 05/12/89
CWS 11	4	1	05/15/89 - 05/19/89	05/15/89 - 05/19/89	05/22/89 - 05/26/89
CWS 12	10	2	06/12/89 - 06/16/89	06/12/89 - 06/16/89	06/19/89 - 06/23/89
CWS 3*	12	40	08/07/89 - 08/11/89	08/07/89 - 08/11/89	08/14/89 - 08/18/89
CWS 13	11	2	09/04/89 - 09/08/89	09/04/89 - 09/08/89	09/11/89 - 09/15/89
CWS 14	8	1	12/04/89 - 12/08/89	12/04/89 - 12/08/89	12/11/89 - 12/15/89

* Note: Two wells from CWS 3 sampled in different sampling periods.

C3.2 Rural Domestic Wells

From April 1988 through February 1990, EPA sampled 783 rural domestic wells in 90 counties in 38 States. Prior to actually collecting drinking water samples from these wells, EPA had to identify a representative sample of wells in each county that met specific NPS eligibility criteria.[5] Once these eligible wells were identified, EPA had to solicit voluntary participation in the Survey from rural domestic well owners and schedule sampling and data collection during designated two-week sampling periods. This scheduling process was cooperatively administered by the NPS data collection and processing staff and the NPS communications staff.

Identification of Geographic Areas to be Sampled

The rural domestic well portion of NPS was designed to obtain information on rural domestic well water use and to collect water samples from approximately 750 rural domestic wells located in 90 counties across the country. Of the 90 counties, six counties had wells selected as part of the pilot study of NPS procedures. During the full field survey, 84 counties remained in which to select wells to be sampled. EPA was particularly interested in sampling water from wells located in areas believed to be more likely to contain pesticide contamination. Thus, the selection of the initial 90 counties oversampled both counties with high pesticide use and those with highly vulnerable groundwater.

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[5] See Appendix B for further explanation of eligibility requirements, numbers of wells in specific counties, and counties selected for sampling.

Starting in March 1988, second stage interviews with county agricultural extension agents were conducted in the 84 counties. The purpose of the interviews was to collect information on cropping patterns and pesticide use for second-stage stratification of rural domestic well sampling. The county agents were asked questions about crop types, pesticide usage, soil textures, crop management practices, irrigation methods, and conservation measures in the counties they served.

Information from the questionnaires was used to make determinations about cropping patterns for each 7.5 minute USGS quadrangle map comprising the county. The maps were then assigned a score to represent the amount of agricultural activity in the quadrangle: greater than 50 percent cropped (high), 26 to 50 percent cropped (moderate), 25 percent or less cropped (low). These cropped areas were overlaid with ground-water vulnerability information (DRASTIC) to identify "cropped and vulnerable" areas for oversampling.

Additional characteristics of the counties were also identified. Some characteristics made an area ineligible (e.g., military bases were excluded from the eligible areas). Other characteristics affected the probability of sampling wells in that area (e.g., all selected wells in vulnerable areas were scheduled for sampling whereas only one well out of three selected were sampled in non-vulnerable areas). Typically, there was an overlap between the land areas with these characteristics. Once the areas were identified on the maps, the ZIP codes for the areas were determined. After identifying different characteristics of areas, the mapping staff defined the boundaries of areas using standard and well-known place designators. These designators (e.g., street names, river names, county boundaries) would be used at a later point in the rural domestic well survey to help respondents determine if their wells were in an eligible, oversampled area.

The steps followed in the mapping process were:

- Locate and obtain a detailed county map which included highways and other landmarks;
- Compare a computerized map of ZIP codes in the county with the 1987 Rand McNally ZIP-Code Map and resolve discrepancies by calling local post offices within the county;
- Indicate target area on each map;
- Determine if the county contained any urbanized areas or was considered rural;
- Draw the urbanized area(s) on the target area map using 1980 Census information; and
- Develop a list of cities for each county which are to be considered ineligible land areas and excluded from the study.

Identification of Telephone Exchange Clusters for Random Digit Dialing (RDD) of Homes

The rural domestic well survey was designed to reach respondents (well owners/residents) and identify private wells by randomly dialing homes in the sampled geographic areas. In order to efficiently identify phone numbers to call, the contractor utilized a modified form of the Waksberg sampling method for random digit dialing. First, a recent list of area codes and telephone exchanges was obtained for the 84 counties selected in the initial sampling. For each area code/exchange combination (six-digits) in each county, all possible values of the next two digits were joined to the six-digit area code and exchange, forming a series of eight-digit numbers. The sampling frame for a county was the set of all possible eight-digit telephone clusters identified for a county.

To select the sample, a random selection was made of eight-digit clusters. A random number in the range of 0 to 99 was also generated and appended to the selected cluster to form a ten-digit telephone number. The number was dialed. If it turned out to be a residential number in the sampled county, the entire cluster of numbers was retained for use in the random digit dialing effort. If the number was not residential, the cluster of telephone numbers was rejected. Estimates were made of the number of wells that would be sampled as a result of calling within a cluster and a determination was made concerning the number of clusters to identify.

Development of the Rural Domestic Well Screening Questionnaire to Determine if a Respondent's Well was Within the Eligible Geographic Area

County residents were called as a result of the random digit dialing effort described above. After verifying that the phone was in a residence and not a business, the respondents were asked a series of questions to establish the location of the residence vis-à-vis the eligibility areas of the county. Using geographic information on the counties developed earlier, the rural domestic well survey research staff drafted a unique questionnaire for each of the 84 counties. The questions identified the precise location of the well. The interviewers posed questions to:

- Identify ZIP codes which included target areas;
- Exclude cities (e.g., Do you live within the city limits of Richmond?);
- Determine the boundaries of the urbanized area when city limit questions did not cover the entire urbanized area, and
- Identify vulnerable (target) areas.

When writing boundary questions for urbanized areas, if the boundaries did not coincide with easily identified landmarks, the boundaries of the urbanized area were enlarged. It was most probable that urbanized areas had grown since the last Census was conducted and the given urban boundaries defined. Similarly, mappers erred to the side of overestimating the boundaries of vulnerable areas (referred to as target area) in order to coincide with well-known and definable boundaries.

The purpose of the activity was to describe the boundaries in such a way that the respondent was able to recognize the area by the description given over the phone. For example, the questions could not include directional references like "north," "south," "east" and "west." (Many people do not correctly interpret such references.) Instead, questions were phrased to describe the areas between two known landmarks, e.g., "Do you live between the Red River and Highway 71?" Estimates of distances were also used, e.g., "Are you within five miles of Gopher Gulch Road?"

Administration of the Rural Domestic Well Screening Questionnaire and Scheduling of Field Team Appointments

The location questions for each of the 84 counties were drafted, typed, and reviewed. The mapping specialists reviewed the questions for each county and compared the named landmarks to the county maps to verify that the correct areas were being singled out. The exercise was repeated with the mapping supervisor. The supervisor was often called upon to make the final decisions about enlarging urban and target area boundaries and other issues that may have affected the sampling probabilities.

Rural domestic well screening interviewers used Computer Assisted Telephone Interviewing (CATI) to administer the Rural Domestic Well Screening Questionnaire. A series of questions on location of the well were integrated into the standard questionnaire administered to the respondent reached through RDD. The RDD calling and administration of Rural Domestic Well Screening questionnaires took place over a period of 17 months. Calls were made to approximately five to ten counties each month with calls to each individual county lasting approximately three weeks.

The Rural Domestic Well Screening questionnaire had the following flow. The interview:

- Determined if the home or well site was eligible for the Survey:
  - Private residence;
  - Located in the sampled county; and
  - A permanent residence for household members.
- Determined if the residence was in an urban area or other area determined to be ineligible for sampling;
- Determined if the residence used water from a private well for domestic purposes (i.e., drinking, bathing or washing);
- If respondent and/or well were deemed to be ineligible based on any of the above criteria, the interview was immediately concluded;
- Determined if the well was in a target area (oversampled);
- If the well was not located in a target area, the CATI program applied a sampling algorithm which included the well with a probability of one in three. The interview was immediately concluded if the respondent's well was not selected. All wells in the target area were selected;
- For sampled cases, the questionnaire continued with questions concerning characteristics of the well; and
- If the well provided water for domestic uses to more than one household, the CATI program applied a second sampling algorithm, and included or excluded the well with a probability based on the total number of households serviced by the well. Similarly, if a household had more than one residential telephone number, it was retained with a probability of one in two. The interview was immediately concluded if the respondent's well was not selected.

Once it was determined that a respondent's well was eligible to be included in the NPS, the screening interviewer asked the respondent to participate in the field Survey. The screening interviewer explained to the eligible respondent that EPA would send a letter and a brochure explaining the purpose of the Survey and the requirements for participation. The screening interviewer then scheduled a sampling appointment within the two-week sampling period for that county, unless the respondent would not schedule a particular time. The screening interviewer also determined whether the respondent was the owner of the well or a resident of the well site who did not own the well. If the respondent was a resident of the site, but did not own the well, the interviewer asked the resident to identify the well owner. In addition, the screening interviewer attempted to identify farmers of the well site property, if applicable. The screening interviewer attempted to get the names, addresses and telephone numbers for farmers of well properties so that interviews with farmers could be arranged.

If the well owner was different from the respondent who agreed to participate, the screening interviewer called the well owner and obtained his or her permission for the field sampling and scheduled a tentative appointment for an interview. If the property resident was different from the respondent who agreed to participate, the screening interviewer called the property resident and got their cooperation for the field Survey and attempted to schedule a tentative appointment.

Confirming Sampling Appointments and Soliciting Participation of Farmers

Once the representative sample was selected for a given county and all screening questionnaires were checked and reviewed, the telephone survey Operations Manager forwarded respondent information sheets logging rural domestic well owners', residents', and farmers' names, addresses, telephone numbers, and sampling appointments to the NPS Communications Manager. (See Exhibit C-3 for a sample respondent information sheet.) The NPS communications staff entered this information into the NPSIS communications data base and forwarded a letter and brochure to each eligible participant (including well owners and farmers) explaining the purpose of the NPS. The well owner was asked to be present during sampling to confirm his or her permission to sample the well, and participate in an interview; a resident who did not own the well was asked to be present during sampling and to participate in an interview; or the farmer was asked to participate in an interview. (See Exhibit C-4 for a sample NPS request for participation letter.) After mailing a letter and brochure to each eligible rural domestic well participant and allowing a reasonable amount of time for mail delivery, NPS communications staff called each eligible well owner in a given county to discuss the NPS. During this call, the interviewer verified each participant's address and phone number and obtained directions to the well site. If the resident had not scheduled an exact time for the appointment during the screener, the appointment was set up during this phone call.

Sampling dates and interview times were recorded in the NPSIS communications data base and a sampling schedule was produced for the sampling team assigned to the county. If the well owner retracted permission to sample, the NPS Communications Manager recontacted the eligible owner within 72 hours and attempted to convert the refusal to a willingness to participate.

One week prior to field sampling, NPS communications staff recontacted rural domestic well participants to confirm the date and time of sampling and interviews. Once in the field, the NPS Sampling Team Leader contacted the participants before the scheduled sampling date to confirm all scheduled appointments. Occasionally, non-resident well owners or well property farmers were "discovered" during the interviews conducted at the sampling appointments. The NPS interviewer contacted these additional owners and farmers and scheduled appointments for interviews. The interviewer also confirmed these appointments one day prior to the interview. These follow-up measures helped to maximize participation in the Survey.

Scheduling Local Area Expert Interviews

In addition to scheduling well sampling and participant interviews, the NPS interviewer also scheduled interviews with County Agricultural Extension Agents or the designated local area expert. The Westat Field Supervisor contacted the county agent by telephone, asked him or her to participate in an interview to provide NPS staff with relevant cropping and pesticide use information, and scheduled a convenient interview time during the two-week sampling period for that county. Interviewers administered the Local Area Expert Questionnaire. This questionnaire collected data on land use in a one-half mile area for each sampled well within a county.

Exhibit C-3
Sample Rural Domestic Well Selection Respondent Information Sheet

Respondent Information Sheet

Date: 06/05/89

Well ID # XX-XX-XXXX

Box 1

Sampled Household

Mr. John Doe
Address: Star Route A Box 100
Phone #: 123-456-7777

Box 2

Appointment with Sampled Household:

Date: 07 / 10 / 89

Time: 09 : 00 a.m.

Box 3

Best time to call:

Usually in the evenings except Wednesday

Box 4

Sampled Household.....

Lives on property where the well is located.	Yes
Owns the well.	No
Farms the property where the well is located.	No

Box 5

Person who lives on property where well is located.

Mr. John Doe
Address: Star Route A Box 100
Phone #: 123-456-7777

Box 6

Person who owns the well.

Mr. Richard Roe
Address: City, State
Phone #: 123-999-9999

Box 7

Person who farms property where well is located.

Mr. Harry Hoe
Address: Star Route C Box 2000
Phone #: 123-888-8888

Box 8

Total number of respondents = 3

Comments:

Respondent could not schedule appointment between June 27 and July 6.

Exhibit C-4
Sample Letter Requesting Participation in Survey

Dear [Resident]:

Recently a member of your household was contacted by telephone about participating in the national survey of pesticides in drinking water wells, which is currently being conducted by the U.S. Environmental Protection Agency.

The purpose of the National Pesticide Survey is to provide EPA with information on the levels of pesticides found in drinking water wells nationwide, and it is the first study of its kind to be conducted on a national scale. It will provide information critical to effective protection of our drinking water resources.

The selection of your well was made through a random statistical procedure; we do not know of or suspect any problems with your water.

EPA has hired ICF Incorporated to conduct the Survey. ICF staff will be contacting you by telephone to arrange a convenient time to visit your home during [the last week of September]. During the visit, you will be asked to complete a 20-minute interview regarding the use and construction of your well and to allow water samples to be taken from an outdoor tap. The water samples will be analyzed in our laboratories, free of charge, and the results will be sent to you.

Your participation is voluntary, and you may refuse to answer any question asked. However, your participation is extremely important to the success of this research and cannot be replaced by someone else. We greatly appreciate your help and cooperation.

Yours sincerely,

Acting Director
National Pesticide Survey

C4 Field Operations and Data Collection

C4.1 Communications

Because of the large number of persons involved in the NPS and the widespread geographical scope of NPS activities, an effective communications system was necessary to coordinate activities. NPS communications activities served to:

- Ensure smooth, timely, and regular communications among project participants;
- Maintain confidentiality regarding rural domestic well owner participation and well sampling results;
- Provide accurate and useful information to well owners/operators and to the numerous parties interested in the Survey;
- Maintain high participation rates among CWS owners/operators and rural domestic well owners/residents; and
- Ensure timely notification of sampling results to EPA and State personnel, CWS owners/operators, and rural domestic well owners/residents.

Communications played a key role during the water sampling phase of the Survey. NPS communications staff supported water sampling and data collection activities by training CWS sampling teams on NPS communications protocols, conducting scheduling of CWS field sampling, providing information to well owners and sampling team members, and notifying State officials and well owners of well sampling results.

NPS Communications Resources

In addition to the NPSIS communications control system used to manage all scheduling activities (see Section C3.7), other major NPS communications resources included the following:

- **NPS Hotline.** EPA established a toll-free NPS telephone information line in March 1988. The hotline was used extensively by State and county officials, CWS and rural domestic well sampling teams, CWS owners/operators, rural domestic well owners/residents, and the general public. The NPS communications staff operated the hotline and responded to inquiries on Survey activities, including scheduling, field sampling, and the status of well sampling results.
- **NPS Mailing List.** EPA maintained an extensive NPS mailing list and periodically mailed the "NPS Project Update" to all interested parties to keep them informed of the Survey's progress. In addition to Survey participants and members of Congress, industry representatives, public interest groups, and trade associations were interested in all aspects of the Survey, from the statistical design of NPS to data analysis and policy development.
- **NPS Project Updates.** EPA published periodic newsletters to inform project participants and interested parties of the progress of the National Pesticide Survey implementation efforts.
- **Health Advisories.** EPA developed Health Advisories for 59 priority pesticides and nitrate using information collected on physicochemical properties, uses, chemical fate, health effects, treatment, and existing criteria and guidelines. These Health Advisories are technical, scientific guidance documents developed to assist in evaluating the results of well sampling and to determine whether the contamination levels found warrant further action. As part of

EPA's effort to improve risk communication, the Agency also prepared non-technical Health Advisory Summaries and distributed these summaries, explaining the health effects of exposure to pesticides and nitrate in simple language, to the owners, residents, and operators of sampled wells where contamination was found.

- **Press Advisories.** The EPA Headquarters Press Office issued press advisories and news releases on NPS activities, and EPA Regional contacts responded to local media inquiries to keep the public informed.

- **Rural Domestic Well Communications.** Rural Domestic Well Field Team Leaders were provided a communications packet for each county sampling assignment. This packet contained the following materials:

  - Sampling schedule;
  - EPA's NPS confidentiality policy;
  - State's confidentiality policy, if applicable;
  - List of EPA and State NPS contacts;
  - Rural domestic well question-and-answer brochure;
  - Non-technical answers to commonly asked questions;
  - Copy of letter to private well owners/residents inviting them to participate in the Survey;
  - Door notice to be used when well owner/resident did not keep a scheduled appointment;
  - Additional copies of materials that could be distributed to local officials, the media, and NPS participants; and
  - NPS interviewers were provided with definitions for terms used in the questionnaire, to be read to the respondent when necessary interviewers were also given answers to questions likely to be asked by the respondent during the interview.

C4.2 Sampling Operations Management

NPS sampling operations were coordinated from a sample preparation room, set up in April 1988. In this preparation room, sample containers were prepared for use; portable meters for measuring temperature, pH, and electrical conductivity at the sampling site were maintained and calibrated; sampling kits were assembled and shipped to the assigned sampling team; and sampling kits and samples were tracked.

Sample Preparation Room Operations

Sampling kit preparation took place at the preparation room at the headquarters of the NPS implementation support contractor in Fairfax, Virginia. The preparation room was a secured area containing facilities for storage of supplies, kit preparation, terminals for the NPS Information System (NPSIS1), and telephones for the NPS Hotline. All sampling operations management thus occurred under secured conditions. The preparation room manager was assigned responsibility for all preparation room activities.

Sample Container Supply, Cleaning, and Preservative Preparation Requirements. An independent vendor provided boxes of cleaned water sample bottles containing the appropriate amounts of sample preservative to the preparation room, where they were stored. Bottle cleaning and the addition of sample preservatives were carried out by the vendor according to a Standard Operating Procedure.[6] After the sample containers were cleaned, the appropriate type and volume of preservative was added to each sample container, depending on the assigned analytic method. Exhibit C-5 summarizes the bottle and cap requirements and preservative requirements for each of the NPS analytic methods. After the bottles were cleaned, filled with the proper amounts of preservative, and capped, they were not reopened until needed at the sampling site.

Preparation of Sampling Kits. Preparation room personnel received shipments of sample bottles, as well as other materials used to prepare sampling kits such as ice chests (coolers), styrofoam containers, styrofoam inserts, plastic liners, and cardboard boxes, and stored all materials in the preparation room and at a readily accessible off-site warehouse. Preparation room personnel then prepared sampling kits, as indicated by the sampling schedule, by carrying out the following steps:

- Printing the appropriate labels and forms;
- Placing the correct bottles and inserts into styrofoam containers, according to the sampling scenario for the site and the laboratory, based on the sampling schedule, and placing the completed kits into cardboard boxes;
- Preparing a sampling supply kit, containing tools and equipment, and placing the kits into a cooler for shipment;
- Shipping the sampling kits and coolers to the proper sampling team; and
- Updating the computer record to show the airbill number, kit type, and date shipped for each kit prepared.

Each of these steps is described in detail in this section.

The overall goals for number of wells to be sampled, shipping blanks, spiked samples, and time storage samples were all entered into NPSIS1 and were used to generate the schedule of sites to be sampled for two-week sampling periods.

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[6] The cleaning procedure for glass sample containers generally involved a hot water/detergent wash, deionized water rinse, and drying at high temperature (400-450°C). Caps for the glass sample containers were washed with detergent and rinsed with deionized water, followed by a solvent rinse. Plastic sample containers and caps were washed with hot water and detergent, followed by a tap and deionized water rinse.

Exhibit C-5
Sample Container Preservation Requirements

NPS METHOD	BOTTLE, CAP, AND PRESERVATIVE*
NPS-1	Clear l-liter borosilicate glass bottles with teflon-lined caps with 10 ml of mercuric chloride.
NPS-2	Clear l-liter borosilicate glass bottles with teflon-lined caps with 10 ml of mercuric chloride.
NPS-3	Clear l-liter borosilicate glass bottles with teflon-lined caps with 10 ml of mercuric chloride.
NPS-4	Clear l-liter borosilicate glass bottles with teflon-lined caps with 10 ml of mercuric chloride.
NPS-5	250 ml amber screw-cap glass bottles with teflon faced septa with 7.5 ml of pH 3 buffer.
NPS-6	60 ml screw-cap glass bottles with teflon-faced septa with 0.6 ml of mercuric chloride.
NPS-7	60 ml screw-cap glass bottles with teflon-faced septa with 0.6 ml of mercuric chloride.
NPS-9	125 ml polyethylene bottles with 0.25 ml of sulfuric acid.

* Volume of preservative should be $\leq$ 1% of the final sample volume for all methods. Concentration of the preservative should be 10 mg/L for all methods.

The current schedule of sites to be sampled indicated the "sampling scenario" to be employed for each laboratory analyzing samples from that site. The sampling scenario, in turn, determined the number of each bottle type to be included in the styrofoam container (the "kit").[7] A sampling scenario for one two-week period for rural domestic wells is shown in Exhibit C-6.

The preparation room staff entered into NPSIS1 the information specific to each laboratory analyzing samples from the site, including the well ID number, the sampling scenario, and the lab three-letter code. In addition, if a spiked sample was assigned to the lab for a particular well, that information was also entered. NPSIS1 then printed the correct number of labels for each type of bottle to be included in each kit for each laboratory. As many as three kits might be prepared for a single laboratory. NPSIS1 also printed the Sample Tracking Form, which listed all sample bottles contained in each kit. The Sample Tracking Form served as the packing list and the means of tracking the sample bottles from the preparation room to the field and from the field to the lab. Exhibit C-7 presents a copy of the Sample Tracking Form. NPSIS1 also printed the Well Sampling Information Sheet, with all pertinent information about the sampling site: the sampling location and address; sampling date, well owner/resident name and phone number, name and address of the person responsible for sampling, and kit numbers. Exhibit C-8 provides a copy of an example Well Sampling Information Sheet.

Sample kits were then prepared using styrofoam containers, styrofoam inserts, and boxes of the correct size and type for the particular kit. Preparation room staff verified that all sample bottles contained preservative prior to affixing sample bottle labels and verified that the correct labels were attached to the correct bottle types. Samples designated as "shipping blanks" were filled with deionized water, and an orange sticker was placed on the top of the cap of the bottle to alert the field team that this sample bottle should not be opened.

After labeling and verifying the correct labeling of bottles, the preparation room staff placed the bottles within the styrofoam container, placed the container in a plastic bag, and placed the container and bag into a cardboard box. Preprinted airbills for shipping the kit from the field to the lab, with the kit number written on the airbill, and the lab and field copies of the Sample Tracking Form were then placed in a plastic bag taped to the top of the styrofoam container. After verifying the address on the airbill corresponded to the address of the lab to which the kit was to be sent from the field, the preparation room staff sealed the cardboard shipping box.

The preparation room staff then placed all necessary field equipment and tools (wrenches, pens, tape) in an equipment bag and placed the bag inside a cooler. Questionnaires were mailed to CWS field teams with the Field Logbook one month in advance of well sampling. Airbills were then placed on the cooler and on all cardboard shipping boxes containing sampling kits. NPSIS1 was updated to indicate the well identification numbers for the kits being shipped and the bottle identification numbers for the bottles in the kits. This shipping data updated the Well Sampling Data base.

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[7] One regular sample and one backup sample were taken for each analytical method at each site. In addition, one shipping blank was always prepared for analytic method 7 for each site. Samples for lab spikes were collected at 30 percent of the sites for Method 1; 20 percent of the sites for Methods 2, 3, and 4; and 10 percent of the sites for Methods 5, 6, 7, and 9 (Method 8 was excluded from the Survey). Samples and duplicate samples for time storage studies were collected at 15 percent of the sites for Method 1; 10 percent of the sites for Methods 2, 3, and 4; and 5 percent of the sites for Methods 5, 6, 7, and 9. Finally, one additional sample for each analytical method was taken at 150 sites for the EPA referee laboratories. The sampling scenario specified for a particular site which of these alternatives the sampling kit should be prepared. When confirmation or follow-up contacts with the domestic well owner or operator suggested that sampling would not be allowed at a well, the NPS preparation room staff were notified by NPS communications staff immediately. If the sampling scenario indicated that time storage samples, referee laboratory samples, or lab spikes should be obtained at that well, the sampling scenario for another well was adjusted to include such samples, to ensure that the necessary number of time storage samples, referee laboratory samples, and lab spikes would be obtained.

Exhibit C-6

NPS Rural Domestic Well Sampling Scenario and Lab Spike Assignments for Two-Week Period (for codes see next page)

							Analytical Method								Referee Lab	
No.	Well ID	Start Date	County	Lab	Scenario No.	Type	1	3	9	2	4	5	7	6	BSL	TSD
422		08/21/89	County A	*	1	FS										
423				ESE**	2	LS						A0	A0			
424					1	FS									1	1
425				ATI	2	LS				B1						
426					1	FS										
427					1	FS										
428				JMM	4	LS	B1									
429					1	FS										
430				BCL	8	LS			A2							
431				JMM	2	LS								A0		
432				JMM	3	LS	B0	B0								
433					2	LS	A0	A0	A0							
434		08/21/89	County B		1	FS										
435				ATI	2	LS				A0					1	1
436					1	FS										
437					1	FS										
438				RAD	2	LS					A0					
439					1	FS										
440					1	FS										
441					1	FS										
442		08/21/89	County C		1	FS										
443					1	FS										
444					1	FS										
445				ATI	2	LS				A1						
446				JMM	4	LS	C0								1	1
447				JMM	3	LS	B1	B1								
448				JMM	7	TS	A2									
449				RAD	2	LS					A1					
450		08/21/89	County D	ESE	2	LS						A1	A1			
451					1	FS										
452					1	FS										
453					1	FS										
454				BCL	2	LS								A1		
455				ATI	2	LS				B0						
456					1	FS										
457					1	FS									1	1

* When no laboratory is indicated, samples were analyzed by all contract laboratories.

** When a particular laboratory is indicated, additional samples were analyzed by that laboratory.

Exhibit C-6 (continued)
Description of Sample Code Numbers for Sampling Scenario and Lab Spike Assignments

PD-0001-1-1-01

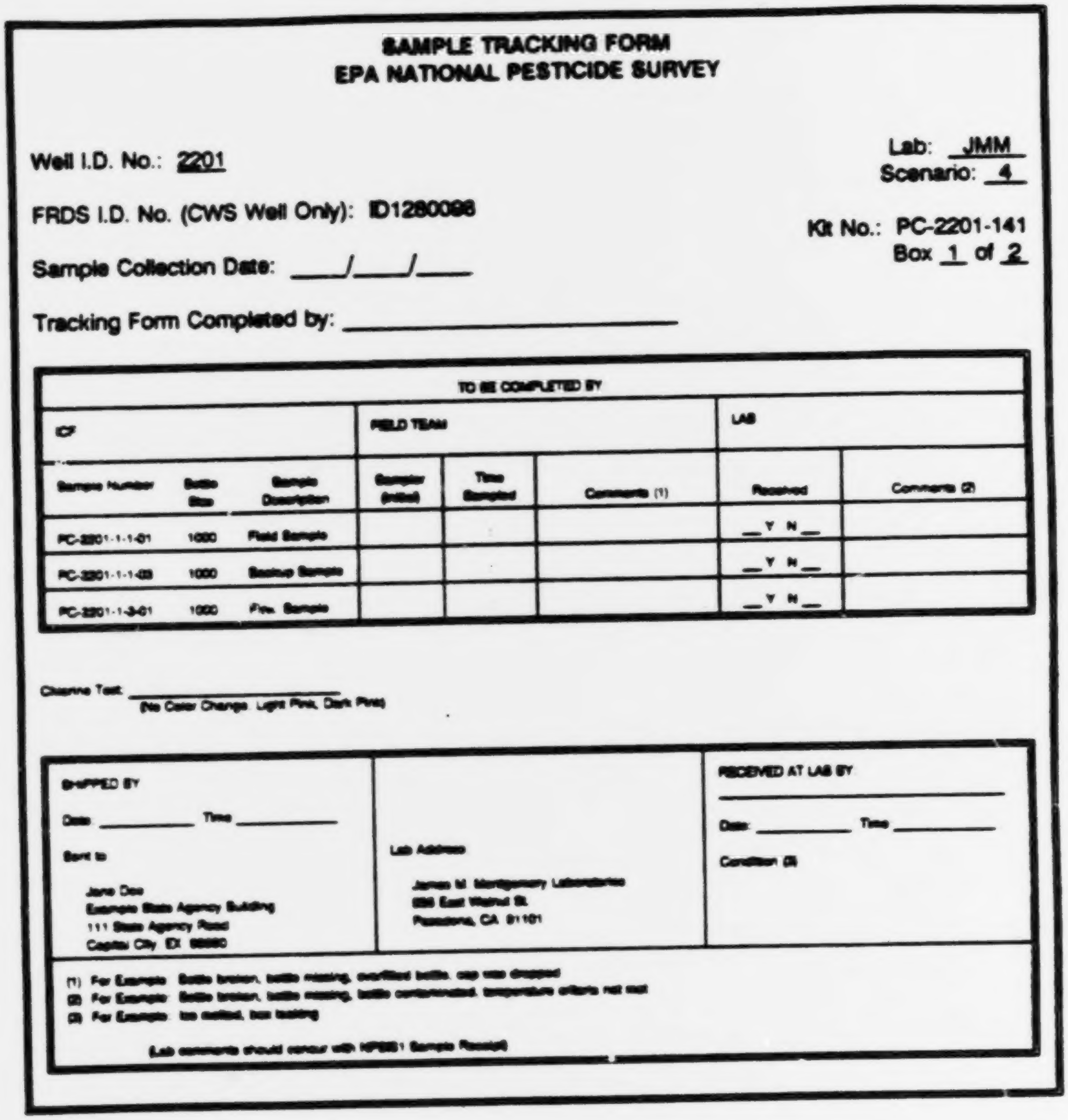
Well Type	ID Number	Lab Name	Method Number	Sample Type
PC = Community Well	0001	1 = JMM	1	01 = Field Sample
PD = Domestic Well	.	2 = ATI	2	02 = Shipping Blank
PR = Resampled Well	.	3 = RAD	3	03 = Backup sample
PB = PE Sample	.	4 = ESE	4	04 = Lab spike (mix A, level 1)=A0
	1500	5 = BCL	5	05 = Lab spike (mix A, level 2)=A1
		6 = BSL	6	06 = Lab spike or time storage - Day 0 (mix A, level 3)=A2
		7 = TSD	7	07 = Lab spike (mix B, level 1)=B0
			9	08 = Lab spike (mix B, level 2)=B1
				09 = Lab spike or time storage - Day 0 (mix B, level 3)=B2
				10 = Lab spike (mix C, level 1)=C0
				11 = Lab spike (mix C, level 2)=C1
				12 = Lab spike or time storage - Day 0 (mix C, level 3)=C2
				13 = Time storage (Day 0 duplicate)
				14 = Time storage - Day fourteen
				15 = Time storage - Day fourteen duplicate

Lab performing the analyses for the NPS:

1 = JMM (Montgomery Laboratories)
2 = ATI (Alliance Technologies Inc./Clean Harbors Analytical Services)
3 = RAD (Radian, Inc.)
4 = ESE (ES&E)
5 = BCL (Battelle, Columbus Division)
6 = BSL (Bay St. Louis (EPA/Environmental Chemistry Lab))
7 = TSD (EPA/Technical Support Division Lab)

FS = Field Sample
LS = Lab Spike
TS = Time Storage

Exhibit C-7
Sample Tracking Form



SAMPLE TRACKING FORM
EPA NATIONAL PESTICIDE SURVEY

Well I.D. No.: 2201

Lab: JMM
Scenario: 4

FRDS I.D. No. (CWS Well Only): ID1280098

Kit No.: PC-2201-141
Box 1 of 2

Sample Collection Date: ___/___/___

Tracking Form Completed by: ____________________

TO BE COMPLETED BY							
ICF			FIELD TEAM			LAB	
Sample Number	Bottle Size	Sample Description	Sampler (initial)	Time Sampled	Comments (1)	Received	Comments (2)
PC-2201-1-1-01	1000	Field Sample				__Y N__	
PC-2201-1-1-02	1000	Backup Sample				__Y N__	
PC-2201-1-3-01	1000	Fbk. Sample				__Y N__	

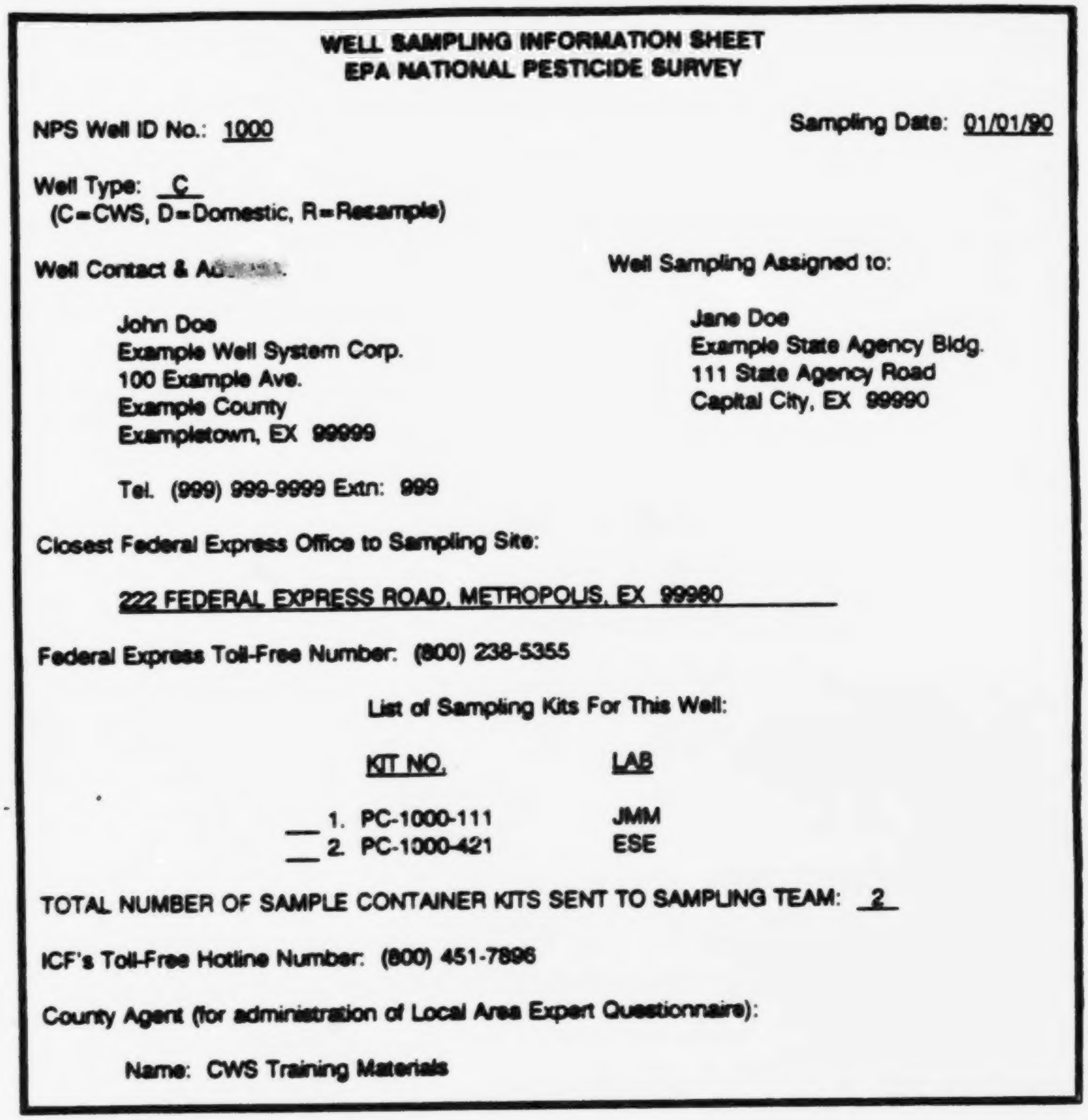
Chlorine Test: ____________
(No Color Change, Light Pink, Dark Pink)

SHIPPED BY Date: ______ Time ______ Sent to Jane Doe Example State Agency Building 111 State Agency Road Capitol City EX 99999	Lab Address James M. Montgomery Laboratories 555 East Walnut St. Pasadena, CA 91101	RECEIVED AT LAB BY ____________ Date: ______ Time ______ Condition (3)

(1) For Example: Bottle broken, bottle missing, overfilled bottle, cap was dropped
(2) For Example: Bottle broken, bottle missing, bottle contaminated, temperature criteria not met
(3) For Example: Ice melted, box leaking

(Lab comments should concur with NPS01 Sample Receipt)

Exhibit C-8
Example Well Sampling Information Sheet



WELL SAMPLING INFORMATION SHEET
EPA NATIONAL PESTICIDE SURVEY

NPS Well ID No.: 1000

Sampling Date: 01/01/90

Well Type: C
(C=CWS, D=Domestic, R=Resample)

Well Contact & Address:

John Doe
Example Well System Corp.
100 Example Ave.
Example County
Exampletown, EX 99999

Tel. (999) 999-9999 Extn: 999

Well Sampling Assigned to:

Jane Doe
Example State Agency Bldg.
111 State Agency Road
Capital City, EX 99990

Closest Federal Express Office to Sampling Site:

222 FEDERAL EXPRESS ROAD, METROPOLIS, EX 99980

Federal Express Toll-Free Number: (800) 238-5355

List of Sampling Kits For This Well:

KIT NO.	LAB
__ 1. PC-1000-111	JMM
__ 2. PC-1000-421	ESE

TOTAL NUMBER OF SAMPLE CONTAINER KITS SENT TO SAMPLING TEAM: 2

ICF's Toll-Free Hotline Number: (800) 451-7896

County Agent (for administration of Local Area Expert Questionnaire):

Name: CWS Training Materials

As the final step of the initial kit preparation and shipment, the cooler and sampling kits were cleared for shipment to the scheduled sampler. All materials were sent about two weeks in advance of the sampling date for CWS and one week in advance for rural domestic well sampling. The Sampling Team Leader was instructed to call the NPS Hotline when the kit was received. Upon receipt of the call, the Sample Kit Tracking System was updated to confirm that the kit was in the possession of the Sampling Team. If the preparation room staff did not receive confirmation from the Sampling Team within three business days of the expected date of receipt for CWS and one business day for rural domestic well sampling, the preparation room staff called the Sampling Team to verify receipt of the kit. If the kit had not been received, or was received with damaged bottles, a Kit Damage Report and a Missing or Damaged Bottle Report were printed, the Sample Bottle Tracking System was updated, and replacement bottles were prepared and shipped.

Finally, after sampling was completed and the kits sent from the field to the labs, the sampling team called the NPS hotline to confirm shipment. Preparation room personnel updated the Sample Kit Tracking System to indicate that the kits had been shipped from the field to the laboratories.

The National Pesticide Survey Information System (NPSIS1) generated management reports designed to track sampling kits, record sampling activities and sampling problems, and provide information about completed wells. Exhibit C-9 lists the reports the Preparation Room staff used in managing the Preparation Room operations.

C4.3 Sampling and Data Collection Techniques and Procedures

NPS sampling and data collection techniques and procedures for both CWS and rural domestic wells were complex, detailed, and precise, and required careful quality assurance to guarantee consistency throughout the Survey. NPS designers divided these techniques and procedures into six major steps, which included prefield sampling preparation, sample collection procedures, after sample collection activities, shipment of samples to laboratories, collection of additional information from local experts, and return of completed questionnaires and other paperwork. Sampling and data collection techniques were discussed in detail in the Field Well Site Water Sampling Manual that was distributed to sampling teams. This section will discuss the major techniques and procedures for collecting water samples; sections C4.4 and C4.5 discuss administration of CWS and rural domestic well questionnaires. Communication procedures were discussed in C4.1.

Prefield Sampling Preparation

Approximately two weeks prior to collecting well water samples, the field team leader received the necessary equipment for sample collection activities from the NPS preparation room staff. This equipment included five to thirteen sample container kits with bottles for each site and a cooler with a pullout tote bag containing sampling equipment supplies. The Field Logbook containing the Well Sampling Information Sheet was provided to each sampling team approximately four weeks prior to sampling. A list of all sample container kits was attached to the Well Sampling Information Sheet for a preliminary inventory check of the kits. Upon the receipt of the sample container kit, the sample team conducted the following activities:

- For each well, removed the Well Sampling Information Sheet from the Field Logbook and conducted an inventory check of the sample container kit numbers listed on the Well Sampling Information Sheet for that well;
- Conducted an inventory of the equipment provided in the tote bag against the Supply Kit Equipment Checklist;
- For each well to be sampled, checked that the well location, contact person, and sampling date were correct on the Well Sampling Information Sheet;

Exhibit C-9
Reports Used in Managing Preparation Room Operations

- Well Schedule Report used to monitor the sampling schedule of wells on a biweekly basis;
- Unconfirmed Well Schedule Report used to monitor selected unconfirmed sampling dates on a biweekly basis;
- Lab Schedule Report used to monitor the kits the laboratories received for analysis on a weekly basis;
- Lab Spike and Time Storage Mix/Level Distribution Report used to monitor the distribution of lab spikes and time storage samples on a weekly basis;
- Kit Tracking Report used to monitor the kits received by the field teams and NPS laboratories on a daily basis. All outstanding kits were monitored for possible delays or other problems throughout the cycle.
- Sample Bottle Tracking Report used to monitor sample kit bottles on a daily basis;
- Misplaced Bottle Tracking Report used to monitor any misplaced bottles on a daily basis. This report was used only when damages were indicated on the Sample Kit Tracking Report;
- Damaged Kit Report used to monitor sample kit damage. This report was used only when damages were indicated on the Sample Kit Tracking Report;
- Missing or Damaged Bottle Report used to monitor sample kit bottles on a daily basis. This report was used only when damages were indicated on the Sample Kit Tracking Report;
- Well Purging Parameters Report used to monitor well purging parameters and comments that the field teams recorded in field logbooks on a monthly basis;
- Incomplete Well Purging Data Report used to monitor wells with incomplete well purging data on a monthly basis;
- Equipment Tracking Report used to monitor field equipment shipments and damages on a weekly basis;
- Method 5 pH Value Report used to monitor pH values for water samples on a monthly basis;
- NPS Completed Wells Report used to tally the completion of wells sampled and the samples received by the NPS laboratories on a weekly basis;
- Process Completion Report used to summarize the preparation and shipment of sampling kits to sampling teams, on a weekly basis;
- Inventory Information Report used to monitor the Preparation Room inventory and the NPS off-site storage of equipment and supplies; and
- Electronic Mail System (EMAIL) served as a computerized communications network between the NPS Preparation Room and the laboratories. EMAIL was used to transmit critical messages from the NPS Preparation Room to the NPS labs about schedule changes, kit damages, and other logistical problems. When a problem was encountered, the Preparation Room staff routinely called the NPS laboratories to convey the necessary information and sent a follow-up message via EMAIL.

- Called Federal Express to determine if the office location printed on the Well Sampling Information Sheet was the nearest office to the sampling site;
- Called the NPS toll-free Hotline (1-800-451-7896) to report receipt of field equipment and reported if kits and supplies had arrived in acceptable condition, or if there were any problems with the kits;
- Removed old Federal Express bar code labels and airbills from the sample container kits and cooler, and crossed out the Federal Express three-character Airport code to avoid confusion when preparing shipments to the laboratories;
- Reconfirmed the sampling appointment and meeting time with the well owner or contact person as needed, and obtained directions on how to get to the well site;
- Assigned specific responsibilities for completion of the Field Logbook and questionnaires, Sample Tracking Forms, and sample collection; and
- Reviewed NPS sampling procedures, forms, and questionnaires and practiced the use of the temperature meter, pH meter, and conductivity meter.

Sample Collection Procedures

For CWS wells, on the day of sampling, the Team Leader arranged to meet the local contact and introduced him/her to the other team members. For rural domestic wells, the introduction to the resident took place upon arrival at the well sites. The team leader explained procedures such as the need to sample from a port or tap closest to the wellhead before any treatment has occurred and that the sampling point should be where water was freshly pumped from the well. The Team Leader also noted that the well pump would need to operate continuously for one to two hours for purging and sampling tasks and that the well port or tap would be kept open until the collection of the last sample. (For CWS wells operating on an automatic mechanism, sampling was done during the automatic pumping cycle or during a manual override of the automatic system).

Before sampling began, the well owner (or resident) answered the questions in the CWS (or Rural Domestic Well) Team Leader Introduction Questionnaire. Upon completion of this brief interview, the team members followed these sampling procedures:

- Located a sampling port or tap as close to the well head as possible and placed a bucket under the tap to collect excess water as needed;
- Measured the air temperature around the well tap using the temperature meter provided in the supply kit and recorded this in the CWS/Rural Domestic Well Purging Parameters Record;
- Opened the well sampling port or tap valve and collected a sample of water in the 1 liter plastic beaker provided in the cooler and immersed the temperature, pH, and conductivity meters into the beaker of water. This initial sample of water from the pipe provided a baseline against which to measure the parameters of the ground-water samples;
- Allowed the water to run five minutes and repeated the three water readings again in the 1 liter plastic beaker. The purpose of this sampling procedure was to observe changes in the parameters from the baseline;

- Again, allowed the water to run for five minutes and retook the three water readings. The purpose of this sampling procedure was to record the parameters as ground water was reached and the levels stabilized. Repeated checks were made at five minute intervals until stability was reached or a maximum of 30 minutes had elapsed. If stability was not reached, the well was not sampled.

- Selected a sample container, removed the enclosed Sample Tracking Form, and checked that there were no broken bottles, that bottles were labeled, and bottle label numbers corresponded to the sample numbers shown on the Sample Tracking Form;

- If the kit contained a shipping blank sample bottle, the sampling team initialed and dated the bottle label with the provided waterproof pen; and

- Using the opened container kit, sampling began with the largest bottle size of 1 L, followed by the 250 milliliter (mL) glass amber bottle, the 125 mL plastic bottle, and the 125 mL glass amber bottle. (Detailed descriptions for the collection of water in each of these bottles is provided in the Field Well Site Water Sampling Manual).

After Sample Collection

Field Team members conducted the following activities upon completion of sample collection:

- Replaced or added ice as needed in each of the sample container kits;

- Removed the Federal Express airbill form inside the ziplock bag outside of the sample container kit lid and resealed the ziplock bag to protect the enclosed Sample Tracking Form;

- Carefully pulled and taped together the ends of the plastic bag that were between the kit and cardboard box;

- Taped the box shut, being careful not to cover the color-coded labels located on two opposite sides of the box and reinforced the bottoms and corners of the boxes with extra tape if signs of wear were apparent;

- Placed the pre-addressed Federal Express airbill in the clear adhesive pouch and affixed it on the appropriate box;

- Completed the CWS/Rural Domestic Well Final Checklist that was contained in the Field Logbook; and

- Searched the well site to ensure that all trash and extra sampling materials had been picked up.

Shipment of Samples to Laboratories

Field team members completed the following procedures to ship samples for laboratory testing:

- Called Federal Express and arranged a pick-up or took the shipment to the nearest Federal Express office;

- Relinquished the sample container kits only to the custody of a Federal Express employee;

- Collected a copy of each of the airbills for the sample container kits from the Federal Express agent;
- Returned all unused sampling and supply kit materials, communication materials, forms, labels, and airbills by placing these materials back in the supply kit cooler and taping the cooler shut;
- Returned all unused communications materials to the NPS Communications manager so that the materials could be reused;
- Shipped the supply kit cooler to the NPS preparation room staff by Federal Express "Standard Air" two-day shipment; and
- Called the NPS Hotline toll-free number and requested the "Sample Tracking System" to confirm that sample container kits had been sent to the laboratories.

Collection of Additional Information from Local Area Expert

One member of the sampling team was responsible for completing the CWS/Rural Domestic Well Local Area Questionnaire by interviewing the local area expert (e.g., county agricultural extension agent). The interviewer made the following arrangements:

- For CWS wells, meet with the local area expert as soon as possible after the completion of well sampling; and
- For rural domestic wells, the Westat Field Supervisor arranged an appointment for the field interviewer to meet the local area expert near the end of the two-week data collection period.

At that time, the local expert answered questions regarding the areas surrounding every sampled well in the county.

Return of Completed Questionnaires and Other Paperwork

The CWS sampling team conducted the following checklist after completion of the questionnaires and all other paperwork:

- Conducted an inventory of the shipment to make sure all the following paperwork was included in the package:
    - A completed CWS Purging Parameters Record form;
    - A completed CWS Main Questionnaire;
    - A completed CWS Team Leader Introduction/Well Observation Record;
    - A completed CWS/Rural Domestic Well Local Area Questionnaire;
    - The Sample Tracking Form (pink copies). The originals from this form were sent with the samples to the appropriate laboratories; and
    - Completed airbills (sender's copies).
- Returned the completed paper work along with the Field Logbook to the EPA Survey contractor in the Federal Express "Courier-Pak" envelope provided.

The Rural Domestic Well Questionnaires were returned separately by the interviewer upon completion of the entire county.

C4.4 Preparation of CWS Field Survey Materials

Survey contractor staff members were responsible for the preparation of all materials needed in the field to conduct CWS interviews. The required materials included:

- Three different questionnaires;
- Bar code labels;
- Random number lists;
- Mailing labels; and
- Custody receipt form.

The schedule for the production and mailout of these materials was directed by a computer program. Contractor staff prepared packages of materials to send to the NPS preparation room, from which the packages were forwarded to the field teams.

The packages included one copy of each of the three questionnaires used in the survey:

1. **Team Leader Introduction/Well Observation Record.** This questionnaire was administered to the CWS owner/operator by a staff member of the State's environmental protection agency or EPA Regional office or State Health Department or, on occasion, by a contractor interviewer at the time the well water samples were drawn. This questionnaire collected information concerning the eligibility, number, plumbing, and location of wells at the CWS.

2. **CWS Main Questionnaire.** This instrument was administered to the CWS owner/operators by a staff member of the State environmental protection agency at the time the water samples were collected. This form collected details concerning the use of the water from the wells and pesticide usage on the property on which the well is located.

3. **Local Area Questionnaire.** This questionnaire was administered to the county's agricultural extension agent for the area. It collected information on pesticide and other chemical uses within one-half mile of each sampled well to help explain potential sources of well contamination. (The CWS and rural domestic versions of this questionnaire were identical.) The questions covered four general areas: (1) pesticides applied within one-half mile of each sampled well; (2) accidental spills of pesticides and hazardous chemicals in the vicinity of each sampled well; (3) other possible influences on ground water within one-half mile of each well site such as golf courses, waste treatment facilities, chemical plants, etc.; and (4) irrigation used within one-half mile of each well.

Included in the packages were continuation sheets to capture lengthy responses. Affixed to each of the questionnaires were bar code labels depicting the CWS ID number. The bar code labels were essential to the subsequent tracking of the Survey instruments throughout the Survey and data processing phases of the study.

The Survey design called for the sampling of one well in each CWS. In the instances where there were multiple wells at a CWS, the field team needed to pick one well at random. To assist the field team, the tracking system generated a sufficient number of random numbers for each CWS and printed these numbers on a label. This label was affixed to the Team Leader Introduction. In case a random selection of a well was needed, the interviewer had only to refer to the label and instructions in the questionnaire for guidance.

The creation of the survey materials package and its shipment to the NPS preparation room automatically marked the starting point for the CWS questionnaire tracking system. After the bar code labels were affixed to blank questionnaires, the bar codes were electronically read, and an entry (date of shipment) made into the tracking system. The tracking system produced a Custody Receipt form to accompany the shipment of packages to the NPS preparation room. The form listed each CWS well ID included in the shipment. Upon receipt, the NPS preparation room staff verified the shipment against the Custody Receipt form, signed it, and returned it.

Custody Receipt. Based on the mailout schedule, all questionnaires were logged into a CWS Questionnaire Tracking System computer program that recorded each one with the current date. The program also simultaneously printed out a Custody Receipt Form showing the identification number of all cases being mailed out. This sheet was checked and the shipment's completeness was verified. All forms were kept in the Custody Receipt Logbook located in the NPS data preparation area.

Used Field Logbooks were shipped back to the Survey preparation room, but not before all questionnaire-related information was removed. The CWS Tracking System generated a Custody Receipt Form showing the ID number of all cases received. The form was then checked against the logbooks on hand to ensure that none were misplaced. The logbooks were then shipped to the Survey preparation room along with the Custody Receipt Form, and receipt of the shipment was verified.

Repeat Visit Cases. If a CWS had a large number of wells, the Survey design included sampling more than one well from that system. These cases were labeled "Repeat Visit Cases" and required material preparation in addition to that described above. Specifically, after the first visit to a CWS had been completed and the questionnaires were returned, the Westat CWS Field Director reviewed the list of wells and randomly selected three of the unsampled wells. The Field Director called the owner/operator of the designated CWS to verify the operability of the wells. To simplify the field operations, the Director incorporated this information in the Team Leader Introduction questionnaire for each sampled well. This questionnaire thus indicated which well to sample and precisely which questions needed to be asked. The tracking system was updated to report the preparation and mailout of the "Repeat Visit Cases." Once all these steps were completed, the case was mailed to the NPS preparation room for shipment to the field team. Though lengthy, this method proved effective in minimizing confusion on the field team's part in selecting wells for water sampling purposes.

Monitoring CWS Progress Through the CWS Tracking System

The CWS questionnaire tracking system ensured the smooth functioning of the survey materials preparation processes. For example, based on scheduling information obtained from ICF and the field, the "Mailout Report" told Westat when to begin survey material preparation and for which specific wells. Requests to the tracking system also prompted the production of the custody receipt forms. In addition, the tracking system anticipated the return of questionnaires. Any case that had not been received within three weeks of the interview/water sampling date was identified overdue on the Overdue Case Report. These overdue notices prompted a telephone call to the field team for an explanation.

The receipt of the questionnaires and their entry into the tracking system as received precluded the Overdue notice. The tracking system monitored cases throughout the subsequent processing steps. A Status Report could be called for at any time which detailed the number of questionnaires in each of the stages. A menu option provided the user with the location of any case, including if it was being held back pending some data clarification on the Tracking System.

Review of Instruments Prior to Data Processing

All materials returned by the field teams were reviewed by editors to identify any problems that needed to be resolved while the team was still in the field. This initial edit included a check for completeness, correct usage of skip patterns, and proper identification of the sampled well. Any problems uncovered at this stage were forwarded to the Field Director for review. The Field Director would determine whether a call needed to be made to the responsible field team members. When materials were incomplete or missing, the Field Director would initiate Data Retrieval, which involved calling the interviewer, and sometimes the respondent, to provide the missing items.

In many of the cases referred to the Field Director, it was apparent that there was a procedural problem, e.g., the field team failed to observe correct procedure in a specific situation. If the Field Director felt it was appropriate, a call was made to the field team to retrain the individual. At the approximate half-way point of the Survey, the Field Director prepared a letter for all field team members noting what aspects of field procedures had proved most problematic, and specifying the correct procedures to be used in those circumstances. This letter was sent out with every subsequent shipment of questionnaires to the field.

C4.5 Preparation of Rural Domestic Well Field Survey Materials

Survey Questionnaires

Three questionnaires were designed for field use for the rural domestic well portion of NPS:

1. **Rural Domestic Well Team Leader Introduction/Well Observation Record.** The Rural Domestic Well Team Leader Introduction collected information concerning eligibility of the well, household water usage during the 24 hours before the water samples were taken from the well, the well piping system, and whether septic systems were located on the well property.

2. **Rural Domestic Well Questionnaire.** The Rural Domestic Well Questionnaire was designed to collect information on water usage, farming and non-farming activities, construction of the well, and pesticide application on the property where the well is located.

3. **Local Area Rural Domestic Well Questionnaire.** The Local Area Rural Domestic Well Questionnaire (LAWQ) was designed to collect information about the area of land within one-half mile of each sampled well to help explain potential sources of well contamination. (The CWS and rural domestic well versions of this questionnaire were identical.) The questions gathered information regarding: (1) pesticides applied within one-half mile of each sampled well; (2) accidental spills of pesticides and hazardous chemicals in the vicinity of each sampled well; (3) other possible influences on ground water within one-half mile of each well site such as golf courses, waste treatment facilities, chemical plants, etc.; and (4) irrigation used within one-half mile of each well. The respondent for this instrument was the local county agriculture extension agent.

Two modified versions of the Rural Domestic Well Questionnaire were used for special circumstances:

- Team Leader Introduction for Interviews Without Water Sampling; and
- Rural Domestic Well Questionnaire Section C for Multiple Farmers.

Preparation of Survey Materials and Field Arrangements

The field schedule produced as a result of the CATI screening was reviewed and modified to address any logistical problems. Materials for the field assignments were then prepared by the Survey implementation subcontractor. This preparation included:

- Arranging for a field team to administer the Survey materials;
- Making all travel and interviewer hotel arrangements for field teams;
- Making appointments for county agent interviews;
- Printing name/address labels for each Survey package and for the individual questionnaires;
- Selecting, labeling, and bundling the appropriate questionnaires;
- Forwarding Survey packet to field teams with the interview schedule; and
- Initializing monitoring system to track progress of Survey materials throughout processes.

C4.6 Rural Domestic Well Field Operations and Monitoring of Survey Task Progress

The field team received the materials and schedule at the beginning of the two-week field period in each county. Twenty-four hours in advance of each scheduled interview, the field team called the home to confirm the home visit on the following day. Frequently at this point, but sometimes at the door of the house, respondents requested changes in the appointment times. Based on their schedule of other appointments, the field team rescheduled as best it could. Changes were called into the Field Director and the NPS hotline.

The field team visited each respondent's home at the designated time. After the Team Leader introduced the team, the interviewer would attempt to identify the correct respondent for the instrument. The object was to speak with the person who was the most knowledgeable about the well and surrounding land activities. It was preferred that one person answer all questions about the well. On occasion it became necessary to interview more than one person. A well owner may lease the land surrounding the well to a farmer. In such a case, the well owner would be asked questions about water usage, the construction of the well, and the non-farm activities (Sections A, B, and D of Rural Domestic Well Questionnaire), but the lease-holder who actually farms the land would be asked about farm use of pesticides (Section C).

More complex situations occurred when, for example, a household used well water from a well on someone else's property. In this situation the household who used the well water was asked water usage questions (Section A), and the person who owned the well was asked about well construction and non-farm activities around the well (Sections B and D).

The questions in Section C of the Rural Domestic Well Questionnaire ask the farmer of the well property to recall farming activities for the five years prior to the interview. On the occasions when property was farmed by more than one farmer over the past five years, the interviewer administered the Rural Domestic Well Questionnaire Section C, Multiple Farmers Questionnaire, to each farmer.

On rare occasions, the appropriate respondent for the Team Leader Introduction and Section A for the Rural Domestic Well Questionnaire was not present when water samples were collected from the well. The interviewer returned to the household later and administered the appropriate sections of the Rural Domestic Well Questionnaire and the Team Leader Introduction for Interviews Without Water Sampling to the correct respondent.

The third questionnaire, the Local Area Rural Domestic Well Questionnaire, was administered to the local county agriculture extension agent. If the Field Director had been unable to schedule the appointment, the field interviewer attempted to schedule an appointment with the pertinent extension agent and administer the questionnaire.

C4.7 Implementation Data Management

The NPSIS I data bases and information system were developed to automate, organize, and centrally locate sampling information, (e.g., scheduling and kit-packing) vital to the day-to-day functions of the NPS. EPA determined that a cost-efficient and effective management strategy would include the use of computers and a customized software system to manage sampling data. The resulting system, named NPSIS (NPS Information System) in its earlier form, enabled the preparation room staff, NPS managers, and communications team to enter and use computerized information. The system used a computer network and communications software that allowed remote access to NPSIS at EPA, the contract laboratories, EPA laboratories, and at NPS contractor offices. It provided an effective means of tracking kits and bottles through the sampling process.

NPSIS I Systems Requirements

The hardware configuration of the system included the following:[8]

- IBM Personal Computers (2) -- not including personal computers used for remote access by laboratories or other EPA or contractor personnel;
- IBM Token Ring Network;
- IBM Token Ring Network Adapter Cards and Cabling(2) -- not including network adapter cards needed for access by other contractor personnel;
- Hayes (or compatible) 2400 Modem, Modem Cabling, and dedicated phone line capable of data transmission;
- Printer -- Epson FX286e Dot Matrix Printer to impact text on polyurethane bottle labels;
- dBase III Plus software package (two);
- Nantucket Clipper language and compiler;
- Carbon Copy communications software (eight) -- one copy for the communications PC and one copy for each remote user;

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[8] Reference to particular products or trade names does not imply EPA endorsement.

- DOS software, version 3.3 or above;
- Polyurethane adhesive bottle labels and triplicate printer forms; and
- The NPSIS I computer software.

NPSIS I Systems Configuration

The NPSIS I system configuration consisted of placing two IBM personal computers in the preparation room. The preparation room was equipped with network plugs and cabling for three personal computers and a phone jack connected to a dedicated (data transmission) phone line.

One PC was programmed to automatically come up as a network server when turned on or rebooted and selected disk directories and their file contents were placed in a network share mode. These shared directories and files house the NPSIS I data bases. The NPSIS I customized software was copied onto the computer.

Another IBM personal computer was installed with an internal modem and programmed to come up on the network as a redirector and to share the NPSIS I data bases with the other computer. Carbon Copy was installed on this PC as the host copy and activated in "call waiting" mode so that the PC would answer any incoming phone calls from the laboratories to the data transmission phone line. The NPSIS I customized software and the Sample Receipts Program, a specialized module of NPSIS I, were copied onto the computer.

A backup system was implemented to ensure against loss of data. Two copies of the data base system and software were saved each night by the preparation room staff using a program written to automate the backup process. Copies of the data and software were stored in the preparation room and an office of an NPS data management team member.

A batch file was copied onto computers elsewhere in the NPS implementation support contractor's building, from which NPSIS I would be accessed. This file performed the necessary commands to access the server computer and start the NPSIS software.

All remote users were sent the Carbon Copy software, a systems requirements document, and a users manual describing how to install Carbon Copy and access NPSIS I.

Implementation Data Management Components

There were five components of the NPSIS I data management system used in implementing the Survey: the Sampling Control System (SCS), the Sample Receipts Program (SRP), the Communications Control System (CCS), the Document Control System (DCS), and the NPS Problem File. Each of these implementation data management systems is described below.

Sampling Control System (SCS)

The SCS was developed to automate information collection, storage, and retrieval for various sampling tasks. The SCS combines data entry, storage, dissemination, and management through a series of user-friendly screens. The SCS was used to facilitate Survey implementation in the following ways:

- Scheduling wells for sampling;
- Assigning the analysis method and kit configurations for each well;
- Printing sample tracking forms, bottle labels, and kit labels;

- Tracking samples through various stages of sampling, from kit preparation through receipt of sample kits at the laboratories, by collecting airbill numbers and providing the capability for the laboratories to report sample receipt and condition;
- Tracking equipment and inventory supplies;
- Providing a key entry system for recording well observation log purging parameters; and
- Generating management reports which describe all phases of sampling.

The NPS Sample Kit preparation staff entered all necessary information, according to standard operating procedures, into the SCS during daily operations. To the fullest extent possible, sampling implementation information was automatically generated by the SCS computer programs. Examples of automatically generated information are: 1) sample bottle information such as identification numbers, bottle size, and sample type, and 2) assignment of bottles and kits to particular laboratories for analysis based on the analysis method used and kit configurations.

Sample Receipts Program (SRP)

The SRP was developed to enable the contract and EPA laboratories to log on to NPSIS I to report sample receipts, report problems with the condition of the kits and samples, check the sampling schedule to determine future sampling flows, and send electronic mail to other laboratories or the NPS implementation support contractor.

The SRP includes a user-friendly set of menus and screens, complete with instructions and help suggestions. The communications software allows remote users to completely control the NPSIS I computer as if they were sitting at the keyboard instead of at their remote terminals. The SRP performs automated QA/QC by rejecting certain types of invalid information, such as invalid ranges or characters for numeric fields. SRP eliminates the need for file transfer, does not include the automated QA/QC features, and does not allow interactive data input or retrieval.

Security features were incorporated into the design of the SRP. Passwords were required for remote access and access through the NPS implementation support contractor's network.

Communications Control System (CCS)

A separate computer system was developed and integrated with the SCS to assist the NPS Communications Group to track rural domestic well sampling schedules, communications information needed to secure voluntary participation from rural domestic well owners, and participation rates.

NPS communications staff entered scheduling and communications information into the computer, and then used CCS to track and manage rural domestic well sampling communications tasks and produce rural domestic well sampling schedules for contractor field sampling teams. This information was also accessible to users of the SCS.

Document Control System (DCS)

A computerized document control system (DCS) was created to provide an efficient way to store and retrieve project records. Documents filed in DCS were given a unique number and identity based on the following items:

- Date;
- Task Number;

- Status (i.e., deliverable, draft, final);
- Author;
- Person the document was submitted to;
- Title;
- Type of document (i.e., briefing, correspondence, publication, report, other); and
- Activity code (i.e. analytical methods, well selection, data management, training, etc.).

This information was key entered into DCS. Documents are located in filing cabinets by searching the document control data base using DCS's menus. The user can identify a particular document or a group of documents based on the identifying items listed above.

The NPS Problem File

A computerized system was developed to document problems associated with sampling that could affect the validity of the analytic results. The system was designed to maintain data on all problems and to retrieve information based on key identifiers, such as well identification numbers and the type of problem encountered. NPS staff were responsible for key entry of information into the problem file. Information stored in this system could be accessed by all NPS staff or disseminated by report.

C4.8 Notification of Results

EPA established strict procedures to ensure the proper dissemination of well sampling results. The NPS communication staff notified well owners and State officials of well sampling results by instituting these procedures to ensure that the privacy of rural domestic well residents and/or owners was protected and to comply with Freedom of Information Act regulations.

Once an individual test result was completed, the contract laboratory sent the results to the NPS Project Director and the NPS implementation contractor. If no pesticides were detected or the concentration of pesticides was below the rapid reporting level, notification of the results was made through the mail; if the concentration of pesticides was found to be above the rapid reporting level, notification was made through an expedited process. Rapid reporting levels for each of the pesticides represented pesticide concentrations that warranted immediate action, and were based on EPA's Lifetime Health Advisory Levels (HALS). Each of these processes is explained in detail below. Except where noted, the notification process was identical for community well system and rural domestic drinking well owners/operators.

Regular Notification

Once the test results were completed, the contract laboratory sent the results to the NPS Project Director and the NPS implementation contractor. If the sample results were below the rapid reporting level or no pesticides or nitrate were detected, the NPS implementation contractor prepared notification packets for the EPA NPS Director that included a transmittal memo, sampling results, sample notification letters, Health Advisory Summaries for any pesticides found in a well, a list of pesticides included in the Survey, a list of pesticides not analyzed, and full analytical results for each method.

The NPS Director reviewed the notification packet, signed the transmittal memo, and forwarded the packet to the Regional and State contacts. The States were urged to notify each system owner/operator in writing within one week of receipt of the results; it was also suggested that States follow up the notification letters with calls to owner/operators whose wells were found to contain pesticides. When notifying rural domestic well owners/operators, the contacts were reminded that the summary results and full laboratory results were confidential. When notifying community well system owners/operators, States were reminded that all sampling information pertaining to community water systems is releasable to the public. However, the States were urged to inform owners/operators of test results in advance of public release of the information. Exhibit C-10 contains a copy of the letter sent to owners/operators of CWS wells that had pesticide or nitrate concentrations below the rapid reporting level.

Once notification was complete, the State's primary responsibility was to answer any questions raised by owners/operators, especially questions related to potential health effects. Each State had its own procedures for responding to questions.

Rapid Notification

In the event of results higher than the rapid reporting level, the NPS Director telephoned the State and Regional contacts to inform them of the results within 24 hours of a laboratory confirmation. Notification packets were express mailed to States within three days of a laboratory confirmation of the results. The State contact was required to call within two days to inform the owner/operator of the results.

In addition to being notified immediately by phone, the owners/operators were sent written notification of the results. The NPS implementation contractor prepared a notification packet containing a transmittal memo, a summary of results, a personalized well owner and/or household resident notification letter, a list of pesticides included in the Survey, and a Health Advisory Summary. The NPS Director reviewed the packet, signed the transmittal memo, and forwarded the packet to the Regional and State contacts.

Upon receipt of the packet, the State photocopied the personal notification letter onto its letterhead, added the date, appropriate State contact information, signature, and sent the packet to the owner and/or household resident within three days of receipt of the packet. Exhibit C-11 contains a copy of the letter sent to owners/operators of rural domestic wells that had pesticide concentrations above the rapid reporting level. If the notification concerned rural domestic wells, States were reminded that the test results and the notification letter were confidential. In cases of community well system notification, the States were reminded that the results were releasable to the public. In addition, the States were urged to include instructions to the system owner/operator on actions required in light of the test results.

During the time that the results were distributed, the State agencies responded to questions regarding the results of the Survey, potential health effects due to pesticides in wells, and any necessary corrective actions. Each State had its own procedure for responding to questions.

C5 Data Base Development

C5.1 NPSIS II

As sampling tasks came to completion, a larger computerized data base and information system, named NPSIS II, was designed to manage the entire body of NPS data. This system includes the NPSIS I data bases as well as the final sample analytic results, questionnaire data, sampling weights, and ground-water related data. The NPSIS II data base system is installed on EPA's mainframe computer system.

Systems Requirements and Configuration

NPSIS II resides on EPA's Cincinnati logical mainframe and the EPA National Computer Center IBM mainframe in a partitioned dataset containing Statistical Analysis System (SAS) files, documentation, and programs to assist users in using and interpreting the data base system. To access NPSIS II, an EPA computer account and computer funding are required.

Exhibit C-10
CWS Standard Test Results Letter
(Positive Contamination Below Health Advisory Levels)

Date: ____________

Well Code #________

Name of Owner/Operator
Name of CWS
Address
City, State, Zip

Dear CWS Owner/Operator:

Several months ago, water samples were taken from the *[name of system]* community water system *[(FTDS #________)]* in *[City/County, State]* as part of the National Pesticide Survey being conducted by the U.S. Environmental Protection Agency (EPA). Testing has been completed for over 100 pesticides and nitrate/nitrite. (See the enclosed List of Pesticides Included in the National Pesticide Survey.)

[Earlier you were informed of our initial findings of pesticides or nitrate/nitrite in your water samples.] Your *[remaining]* test results are shown below. The levels at which contaminants were found are not considered to pose a health risk. An EPA Health Advisory Summary is enclosed for each contaminant found.

State's instructions to the CWS owner/operator on actions to take, if any, should be inserted here.

For more information, please contact the State office listed below:

Contact: ____________________

Office: ____________________

Tel: ____________________

Yours sincerely,

Enclosures

Exhibit C-11

Rural Domestic Well Owner Standard Test Results Letter (Positive Contamination Above Health Advisory Level)

Date: ______________

Well Code #________

Name of Owner
Address
City, State, Zip

Dear Well Owner:

Recently, water samples were taken from your well as part of the National Pesticide Survey being conducted by the U.S. Environmental Protection Agency (EPA). The samples are being tested for over 100 pesticides and nitrate/nitrite. (See the enclosed list.)

In testing the samples, to date we have discovered the following: Your water sample contained ____ milligrams per liter* of __________. This is above EPA's Guidance Level of ____ milligrams per liter of __________.

An EPA Health Advisory Summary is enclosed for the contaminant found. EPA is continuing further tests on your water samples for the presence of additional pesticides. We will inform you of those results as soon as they are available.

For more information, please contact the State office listed below:

Contact: ______________________

Office: ______________________

Tel: ______________________

Yours sincerely,

* Micrograms per liter is the unit of measurement for contaminants in water, equivalent to parts per billion. Milligrams per liter is a common unit of measurement for nitrate/nitrite in water, equivalent to parts per million.

Analytic Results Data Management

The analytic results were entered by contract and EPA laboratory staffs. Analytic results were processed at the EPA laboratory in Cincinnati, where QA/QC checks were performed. The analytic results were retrieved from the EPA mainframe computer system and linked, or merged, with the information stored in SCS. The merged data were then processed to generate the following reports:

- Community water system owner/operator notification of results reports;
- Rural domestic well sampling homeowner (and resident, if homeowner does not reside at well site) notification of results reports;
- Summary results reports; and
- Freedom of Information Act reports.

Questionnaire Data

Survey questionnaire data were collected during sampling to augment the analytic results data. The Survey instruments and methods used to collect this data are:

- For rural domestic well sampling: Rural Domestic Well Survey Main Questionnaire, Local Area Questionnaire, Team Leader Introduction and Well Observation Record; and
- For community water system sampling: Community Water System Main Questionnaire, Local Area Questionnaire, Team Leader Introduction and Well Observation Record.

Questionnaire data were key entered and QA/QC checks were performed according to standard operating procedures. The data were then integrated into the final data analysis system.

C5.2 Questionnaire Data Base Development

This section details the steps and procedures that were observed in preparing the data collected through the questionnaires for computerized processing and the creation of national estimates.

Overall, both CWS and rural domestic well questionnaire materials were processed in accordance with the following standard procedures, and modified, when necessary, to apply to the unique aspects of the CWS and rural domestic well survey. The general steps followed in preparing questionnaire data are:

- Receipt of materials from field staff;
- Entry of receipt into Tracking System;
- Scan edit for serious problems (CWS) or thorough edit by the Field Supevisor (DWS);
- Data retrieval of vital information, if necessary;
- Coding batch formation via the Tracking System;
- Batches coded for clarity and assignment of codes to open-ended questions;
- Key entry batch formation via the Tracking System;

- Batches forwarded to key entry;
- Batches key entered and key verified;
- Questionnaires returned to coders/editors;
- Computerized range and logic checks conducted, errors corrected;
- Advanced/additional computerized logic checks conducted, errors corrected;
- Data retrieval calls made to appropriate respondents if necessary to resolve discrepancy;
- Corrections entered into data;
- "Checking and correcting" reexecuted until data base is considered "clean"; and
- Data base further developed (imputation performed and weighting applied) so that national estimates can be made for the data items.

Details concerning imputations and weighting of the data base for national estimates are found in Appendix B.

Review of Completed Survey Instruments Prior to Data Processing

The field team returned the Survey package materials at the conclusion of the interviewing in a county (rural domestic wells only). The packages were opened and receipt notations were entered in the manual receipt control system. Bar code labels on each Survey instrument indicating the well ID were scanned into the computerized receipt control system. These bar codes were pivotal to the tracking of each instrument throughout the data processing phase.

The Field Director reviewed each return initially to spot major breaches in established procedure. When necessary, calls were made to the field team to clarify points or to send the team back to the home or well for data clarification. Materials were then batched and forwarded to the coder/editor teams.

Advanced Preparation

In advance of the actual return of Survey materials, code books were established for the CWS and rural domestic well survey forms. The code books specified characteristics of each variable (e.g., number of positions, type of format), the record structure and the placement of fields on the records, unambiguous and clear code systems (1=Yes, 2=No), and consistencies that should be observed in the data (e.g., logical limits on values of variables, relationships between variables.) These range limits and logical relationships were built into the computerized data checking software (COED) and applied to the incoming data. After the first several batches of actual materials were processed, the criteria were reviewed and some changes were made to criteria in light of actual field findings.

Receipt of Field Materials and Coding

Upon receipt, all field materials were logged into the computerized document tracking system. The CWS questionnaires were submitted to an initial scan edit to identify any immediate and serious problems that needed to be resolved by the field team. Questionnaires for rural domestic wells were reviewed thoroughly by the Field Supervisor. After this initial edit, the questionnaires were sorted into batches of approximately 20 using the Tracking System. Logs were printed that listed each questionnaire in the batch.

The questionnaires were passed to coders who reviewed all data fields and made corrections and clarifications in accordance with the code book and data coding guides. A special feature of the coding instructions was a notation that coders could turn on if they felt that a particular question needed evaluation by a specialist with a hydrogeological background. A special program was written that singled out cases with such flags for the most important variables, which were then given extended and substantive review.

Data Entry

After coding, the batches of 20 questionnaires were combined into batches of approximately 40 via the Tracking System and were forwarded to the data entry staff for key entry. Logs were printed that listed each questionnaire in that batch.

The data entry staff, in advance, had prepared customized key entry programs to facilitate the speedy and accurate entry of CWS and rural domestic well information into the system. The materials received by data entry were keyed and 100 percent rekeyed by a different operator for verification. Any discrepancies were flagged and evaluated. Simple errors were corrected; ambiguities were referred to the Coding Supervisor for clarification and resolution. After each correction was made, the record was 100 percent rekeyed and key verified to ensure that errors were not introduced in the course of making corrections.

Expert Review

The expert review of confusing or difficult field findings was conducted by the Field Director and a contractor staff member familiar with the Survey. This specialist reviewed the comments provided by the Field Team and the coder and made a judgment as to the correct code to be applied to the data item(s) in question in accordance with coding procedures.

Data Retrieval

Missing or inconsistent responses in NPS data were corrected through a process known as data retrieval. Data retrieval began with the identification of problems by the computerized edit checking programs conducted on the data files. The problems were summarized in writing and submitted to the data retrieval staff, who obtained the appropriate original Survey questionnaire and made a telephone call to the appropriate respondent. The problem was explained to the respondent and the resolution made. The data retrieval specialist wrote up the correction and indicated the correction to be imposed on the raw data base. This correction was submitted to key entry and the data base was updated. The computerized logic checks were rerun to verify that the problem no longer existed and that new problems were not introduced.

Data retrieval efforts were limited to correcting key variables. In order to be subject to data retrieval, a variable had to be designated as "key" by EPA or it had to have a logical relationship with a key variable.

The instructions for data retrieval were very specific about who could provide answers for the data retrieval questions. Acceptable respondents were detailed on a question-by-question basis. This constraint was imposed to ensure that accurate data were obtained whenever possible.

Passage of Data Files to Analytic Staff

When all data preparation steps were completed, the data files were moved to a separate computer account for use by the analytic staff for the purpose of imputing missing data fields and applying weights that would produce national estimates.

National Pesticide Survey

Appendix D: Questionnaire Data and Questionnaires

Appendix D: Questionnaire Data and Questionnaires

D1 Introduction

One of the purposes of the NPS is to investigate the relationship between the presence of pesticides and nitrate in drinking water wells and a number of factors potentially affecting that presence. In order to gather data on well construction and maintenance, farming activities conducted in the vicinity of wells, and pesticide use, several detailed questionnaires were administered to the owners or operators of wells, householders using rural domestic wells, farmers, and local area experts such as county agricultural extension agents. Questionnaires used to compile the data include the CWS and Domestic Well Team Leader Introduction (TLI) and Well Observation Record (WOR), the CWS and Domestic Well Main Questionnaires (CWS Main and DWS Main), and the CWS and Domestic Well Local Area Questionnaires (LAQ).

This appendix consists of seven exhibits, one for each domain of interest, that present estimates and confidence intervals for well characteristics. In addition this appendix contains copies of the questionnaires used to obtain the raw data.

The seven exhibits present national estimates based on questionnaire data for:

- CWS wells in the United States (Exhibit D-1);
- CWS wells in counties with high vulnerability (Exhibit D-2);
- Rural domestic wells in the United States (Exhibit D-3);
- Rural domestic wells in counties with high pesticide use (Exhibit D-4);
- Rural domestic wells in counties with high ground-water vulnerability (Exhibit D-5);
- Rural domestic wells in "cropped and vulnerable" county subregions (Exhibit D-6); and
- Rural domestic wells in counties with high pesticide use and high ground-water vulnerability (Exhibit D-7).

Caution should be exercised in making comparisons between domains for similar characteristics because the confidence intervals (indicated in the exhibits as 95% C.I.) do not account for the relationship between domains or between characteristics (i.e., each confidence interval is calculated separately or independently). All confidence intervals presented in this appendix are based on the normal distribution approximation to the binomial distribution.

A parallel numbering system is used in the exhibits, but that system does not correspond to the numbering used in Survey questionnaires. The exhibits also provide the identity of the questionnaire(s) and question(s) from which the data are derived (e.g., CWS TLI #14 indicates that the data source is question #14 of the CWS Team Leader Introduction).

Some questionnaire items contain skip patterns (i.e., instructions to skip particular questions depending upon previous answers). A questionnaire item is presented as a single item including sub-items resulting from skip patterns, which are separated from the leading item with a blank line.

Number and percent estimates for responses to particular questions sum exactly to the domain population size and one hundred percent, respectively, when the possible Survey responses are mutually exclusive and exhaustive. Rounding can cause the summations to be inexact (number estimates are generally rounded to 3 significant digits, and percent estimates are rounded to 1 decimal place). In addition, summations may not equal the population size or one hundred percent for a few questionnaire items that do not contain a mutually exclusive or exhaustive list of possible responses.

For particular responses to questionnaire items when the percent is extreme (i.e., near 0.0% or 100.0%) and the sample size is relatively small, the 95% confidence intervals should be treated with caution. When the percent is equal to 0.0% or 100.0%, traditional 95% confidence intervals based solely on sampling error are not applicable. For further details see Section B6.4 of Appendix B.

Exhibit D-1

Estimated Number and Percent of Community Water System Wells in the United States

Item	Questionnaire Item	National Estimates for CWS Wells			
		Number	(95% C.I.)	Percent	(95% C.I.)
I.1 CWS TLI #8	Number of wells that belong to systems with:				
	One working well	15,900	(± 3,080)	16.8	(± 3.4)
	Two working wells	26,200	(± 3,810)	27.7	(± 4.0)
	3-5 working wells	27,000	(± 4,390)	28.5	(± 4.2)
	6-10 working wells	7,850	(± 2,220)	8.3	(± 2.4)
	> 10 working wells	17,800	(± 2,710)	18.8	(± 2.7)
I.2 CWS TLI #14	Septic system within 300 feet of well:				
	Septic tank	19,100	(± 2,780)	20.2	(± 2.8)
	Septic field	17,700	(± 2,890)	18.8	(± 2.9)
	Cesspool	2,220	(± 1,650)	2.4	(± 1.7)
I.3 CWS WOR #1	Topographic setting at well:				
	Hilltop	11,000	(± 2,750)	11.6	(± 2.9)
	Hillside	18,900	(± 3,040)	20.0	(± 3.4)
	Flat valley	30,700	(± 4,180)	32.5	(± 4.1)
	Depression	3,380	(± 1,380)	3.6	(± 1.5)
	Plateau	9,510	(± 2,620)	10.1	(± 2.9)
	Other	20,600	(± 3,700)	21.7	(± 3.5)
	Don't know	570	(± 600)*	0.6	(± 0.6)*
I.4 CWS WOR #4	Description of land area within 300 feet of well:				
	Roofed	4,060	(± 1,600)	4.3	(± 1.7)
	Paved	3,520	(± 1,380)	3.7	(± 1.5)
	Graveled	4,320	(± 1,480)	4.6	(± 1.6)
	Exposed or vegetated soil	68,500	(± 4,300)	72.4	(± 4.3)
	Other	14,200	(± 4,070)	15.0	(± 4.1)
I.5 CWS WOR #3	Well protection at surface:				
	Well house or shed	53,000	(± 5,170)	56.0	(± 4.3)
	Concrete pad	73,800	(± 4,160)	78.0	(± 3.1)
	Sanitary or grouted seal	65,500	(± 5,150)	69.2	(± 4.3)
	Covered pit	7,500	(± 2,120)	7.9	(± 2.3)
	Other	15,600	(± 3,370)	16.5	(± 3.4)

Exhibit D-1 (cont'd)

Estimated Number and Percent of Community Water System Wells in the United States

Item	Questionnaire Item	National Estimates for CWS Wells			
		Number	(95% C.I.)	Percent	(95% C.I.)
I.6 CWS Main A.1	Age of well:				
	< 5 years	5,900	(± 1,550)	6.2	(± 1.6)
	5 to 10 years	16,300	(± 2,700)	17.2	(± 3.1)
	11 to 20 years	26,700	(± 4,290)	28.2	(± 4.5)
	> 20 years	33,600	(± 5,750)	35.6	(± 5.4)
	Don't know	12,000	(± 3,360)	12.7	(± 3.6)
I.7 CWS Main A.2	Well redrilled:				
	Yes	4,530	(± 1,570)	4.8	(± 1.6)
	No	84,700	(± 4,370)	89.6	(± 2.7)
	Don't know	5,330	(± 2,220)	5.6	(± 2.4)
I.8 CWS Main A.5	Well depth:				
	< 20 feet	260	(± 510)*	0.3	(± 0.6)*
	20 to 50 feet	4,410	(± 2,470)	4.7	(± 2.6)
	51 to 100 feet	14,900	(± 3,180)	15.8	(± 3.2)
	101 to 200 feet	16,600	(± 3,300)	17.6	(± 3.4)
	201 to 500 feet	33,400	(± 4,450)	35.3	(± 4.4)
	> 500 feet	19,800	(± 3,530)	20.9	(± 3.8)
	Don't know	5,150	(± 2,270)	5.5	(± 2.4)
I.9 CWS Main A.7	Well casing information:				
	Well cased	93,600	(± 3,720)	99.0	(± 0.8)
	Well not cased	220	(± 300)*	0.2	(± 0.3)*
	Don't know casing	720	(± 670)	0.8	(± 0.7)
CWS Main A.11	Cased to total depth	43,300	(± 4,410)	46.2	(± 4.6)
	Cased < total depth	40,300	(± 4,260)	43.0	(± 4.2)
	Don't know casing depth	10,100	(± 3,100)	10.8	(± 3.2)
CWS Main A.13	Screens in casing	49,000	(± 3,130)	52.3	(± 3.2)
	No screens in casing	32,300	(± 4,110)	34.5	(± 4.0)
	Don't know screening	12,400	(± 2,770)	13.3	(± 2.9)
CWS Main A.18	Well grouted	65,200	(± 4,700)	69.6	(± 4.1)
	Well not grouted	10,700	(± 2,660)	11.5	(± 2.8)
	Don't know grouting	17,700	(± 3,400)	18.9	(± 3.6)

Exhibit D-1 (cont'd)

Estimated Number and Percent of Community Water System Wells in the United States

Item	Questionnaire Item	National Estimates for CWS Wells			
		Number	(95% C.I.)	Percent	(95% C.I.)
I.10 CWS Main A.21	Well capped at ground surface:				
	Well capped	79,300	(± 5,440)	83.9	(± 3.6)
	Well not capped	15,100	(± 3,200)	16.0	(± 3.6)
	Don't know if capped	110	(± 190)*	0.1	(± 0.2)*
I.11 CWS Main A.23	Distance from the ground surface to the water surface in the well:				
	< 20 feet	13,700	(± 3,350)	14.5	(± 3.4)
	20 to 50 feet	20,500	(± 3,430)	21.7	(± 3.4)
	51 to 100 feet	14,100	(± 3,620)	14.9	(± 3.7)
	101 to 200 feet	12,800	(± 3,020)	13.6	(± 3.2)
	201 to 500 feet	9,520	(± 1,990)	10.1	(± 2.1)
	> 500 feet	690	(± 740)*	0.7	(± 0.8)*
	Don't know	23,200	(± 4,320)	24.6	(± 4.8)
I.12 CWS Main A.25	Aquifer:				
	Confined	41,100	(± 5,080)	43.5	(± 5.0)
	Unconfined	36,400	(± 4,400)	38.5	(± 4.3)
	Don't know	18,930	(± 3,800)	20.0	(± 4.0)
I.13 CWS Main A.37	Abandoned or non-operating wells within 500 feet of the well:				
	Yes	20,800	(± 4,160)	22.0	(± 4.2)
	No	69,000	(± 4,960)	73.0	(± 4.8)
	Don't know	4,740	(± 1,930)	5.0	(± 2.0)
I.14 CWS Main B.1	Non-farm pesticides used in the last 3 years:				
	Non-farm pesticides used	24,100	(± 3,420)	25.5	(± 3.5)
	Not Used	67,300	(± 4,670)	71.2	(± 3.7)
	Don't know whether used	3,190	(± 1,520)	3.4	(± 1.6)
CWS Main B.3	Used < 100 feet from well	17,700	(± 3,500)	73.5	(± 9.1)
	Used ≥ 100 feet from well	3,400	(± 1,750)	14.1	(± 7.0)
	Don't know distance	2,990	(± 1,120)	12.4	(± 4.8)

Exhibit D-1 (cont'd)

Estimated Number and Percent of Community Water System Wells in the United States

Item	Questionnaire Item	National Estimates for CWS Wells			
		Number	(95% C.I.)	Percent	(95% C.I.)
I.15 CWS Main B.4	Non-farm pesticides stored for more than 1 month in the last 3 years:				
	Non-farm pesticides stored	5,040	(± 2,150)	5.3	(± 2.2)
	Not stored	88,500	(± 3,950)	93.6	(± 2.5)
	Don't know whether stored	1,050	(± 1,170)*	1.1	(± 1.3)*
CWS Main B.5	Closest storage < 100 feet	3,150	(± 1,860)	62.4	(± 24.7)
	Closest storage $\geq$ 100 feet	1,890	(± 1,460)	37.6	(± 24.7)
	Don't know distance	0	N/A	0.00	N/A
I.16 CWS Main B.6	Non-farm pesticide container disposal in the last 3 years:				
	Containers disposed	190	(± 380)*	0.2	(± 0.4)*
	No disposal	93,500	(± 3,660)	98.9	(± 0.8)
	Don't know	900	(± 680)	1.0	(± 0.7)
I.17 CWS Main B.8	Accidental spill of non-farm pesticide in the last 3 years:				
	Non-farm pesticides spilled	0	N/A	0.0	N/A
	No spill	93,300	(± 3,780)	98.6	(± 0.9)
	Don't know	1,320	(± 890)	1.4	(± 0.9)
I.18 CWS Main C.1	Property farmed in the last 5 years:				
	Yes	7,040	(± 3,510)	7.4	(± 3.7)
	No	87,100	(± 5,030)	92.1	(± 3.7)
	Don't know	430	(± 270)	0.5	(± 0.3)
CWS Main C.2	Pesticides used	2,420	(± 1,800)	34.4	(± 18.0)
	Not used	2,020	(± 1,460)	28.7	(± 15.1)
	Don't know whether used	2,600	(± 1,760)	36.9	(± 21.7)
I.19 CWS Main C.5	Farm pesticides stored for more than 1 month in the last 5 years:				
	Farm pesticides stored	640	(± 820)*	0.7	(± 0.9)*
	Not stored	93,100	(± 3,630)	98.4	(± 1.3)
	Don't know whether stored	890	(± 820)	0.9	(± 0.9)

Exhibit D-1 (cont'd)

Estimated Number and Percent of Community Water System Wells in the United States

Item	Questionnaire Item	National Estimates for CWS Wells			
		Number	(95% C.I.)	Percent	(95% C.I.)
I.20 CWS Main C.7	Farm pesticide containers disposed on the property in the last 5 years:				
	Containers disposed	190	(± 380)*	0.2	(± 0.4)*
	No disposal	92,900	(± 3,830)	98.2	(± 1.3)
	Don't know	1,490	(± 1,120)	1.6	(± 1.2)
I.21 CWS Main C.9	Accidental spill of farm pesticide on the property in the last 5 years:				
	Farm pesticides spilled	150	(± 300)*	0.2	(± 0.3)*
	No spill	91,400	(± 3,740)	96.6	(± 1.4)
	Don't know whether spill	3,030	(± 1,280)	3.2	(± 1.3)
I.22 CWS LAQ #1	Crops farmed within 1/2 mile of well in the last 3 years:				
	Yes	38,200	(± 3,790)	40.3	(± 3.7)
	No	48,800	(± 4,610)	51.6	(± 4.4)
	Don't know	7,620	(± 3,180)	8.1	(± 3.4)
I.23 CWS LAQ #3	Land used for pasture within 1/2 mile of well in the last 3 years:				
	Yes	38,800	(± 4,310)	41.0	(± 3.9)
	No	45,400	(± 4,500)	48.0	(± 4.6)
	Don't know	10,500	(± 2,700)	11.1	(± 2.9)
CWS LAQ #4	Pesticides Used	21,700	(± 3,120)	57.2	(± 5.6)
	Not used	16,100	(± 2,860)	42.3	(± 5.5)
	Don't know	200	(± 390)*	1.5	(± 1.0)*
I.24 CWS LAQ #5	Major non-agricultural pesticide application within 1/2 mile of well in the last 3 years:				
	Yes	18,700	(± 2,860)	19.8	(± 2.9)
	No	54,400	(± 4,670)	57.5	(± 4.4)
	Don't know	21,500	(± 4,300)	22.8	(± 4.5)

Exhibit D-1 (cont'd)

Estimated Number and Percent of Community Water System Wells in the United States

Item	Questionnaire Item	National Estimates for CWS Wells			
		Number	(95% C.I.)	Percent	(95% C.I.)
I.25 CWS LAQ #7	Accidental spill of any pesticide within 1/2 mile of well in the last 3 years:				
	Yes	95	(± 190)*	0.1	(± 0.2)*
	No	68,400	(± 4,630)	72.3	(± 4.6)
	Don't know	26,100	(± 4,680)	27.6	(± 4.6)
I.26 CWS LAQ #9	Accidental spill of any hazardous chemical within 1/2 mile of well in the last 3 years:				
	Yes	1,340	(± 730)	1.4	(± 0.8)
	No	64,600	(± 4,750)	68.3	(± 4.5)
	Don't know	28,700	(± 4,320)	30.3	(± 4.4)
I.27 CWS LAQ #11j	Golf course within 1/2 mile of well:				
	Yes	8,990	(± 2,210)	9.5	(± 2.3)
	No	84,400	(± 3,790)	89.2	(± 2.6)
	Don't know	1,220	(± 870)	1.3	(± 0.9)
I.28 CWS LAQ #2	River, canal, bay, spring, pond, etc. within 1/2 mile of well:				
	Yes	78,800	(± 4,390)	83.3	(± 3.2)
	No	9,490	(± 1,980)	10.0	(± 2.2)
	Don't know	6,290	(± 2,620)	6.7	(± 2.7)
I.29 CWS LAQ #13	Irrigation within 1/2 mile of well:				
	Yes	23,700	(± 3,330)	25.0	(± 3.6)
	No	63,600	(± 4,840)	67.2	(± 4.2)
	Don't know	7,340	(± 2,740)	7.8	(± 2.8)

* For particular responses to questionnaire items where the percent is extreme (i.e., near 0.0% or 100.0%) and the sample size is relatively small, the 95% confidence intervals should be treated with caution. For further details see Section B6.4 of Appendix B.

N/A For particular responses to questionnaire items where the percent is equal to 0.0% or 100.0%, traditional 95% confidence intervals based solely on sampling error are not applicable. For further details see Section B6.4 of Appendix B.

Exhibit D-2

Estimated Number and Percent of Community Water System Wells Belonging to Counties with High Vulnerability

Item	Questionnaire Item	Estimates for CWS Wells in Counties with High Vulnerability			
		Number	(95% C.I.)	Percent	(95% C.I.)
II.1 CWS TLI #8	Number of wells that belong to systems with:				
	One working well	3,160	(± 1,130)	15.2	(± 5.7)
	Two working wells	5,690	(± 970)	27.3	(± 4.0)
	3-5 working wells	5,300	(± 1,940)	25.5	(± 9.4)
	6-10 working wells	2,470	(± 1,000)	11.9	(± 4.7)
	> 10 working wells	4,180	(± 890)	20.1	(± 3.8)
II.2 CWS TLI #14	Septic system within 300 feet of well:				
	Septic tank	5,230	(± 1,310)	25.1	(± 6.4)
	Septic field	4,350	(± 1,040)	20.9	(± 5.1)
	Cesspool	190	(± 370)*	0.9	(± 1.8)*
II.3 CWS WOR #1	Topographic setting at well:				
	Hilltop	1,540	(± 640)	7.4	(± 3.1)
	Hillside	2,110	(± 1,000)	10.2	(± 4.8)
	Flat valley	6,130	(± 1,010)	29.5	(± 5.4)
	Depression	700	(± 570)	3.4	(± 2.7)
	Plateau	2,010	(± 1,050)	9.7	(± 5.1)
	Other	8,210	(± 1,770)	39.5	(± 7.5)
	Don't know	100	(± 230)*	0.5	(± 1.1)*
II.4 CWS WOR #4	Description of land area within 300 feet of well:				
	Roofed	1,590	(± 630)	7.7	(± 3.0)
	Paved	1,240	(± 380)	6.0	(± 1.9)
	Graveled	650	(± 700)*	3.1	(± 3.4)*
	Exposed or vegetated soil	14,900	(± 1,220)	71.5	(± 4.8)
	Other	2,440	(± 890)	11.8	(± 4.2)
II.5 CWS WOR #3	Well protection at surface:				
	Well house or shed	12,100	(± 1,370)	58.2	(± 6.2)
	Concrete pad	17,300	(± 1,080)	83.3	(± 3.6)
	Sanitary or grouted seal	14,700	(± 1,830)	71.0	(± 7.4)
	Covered pit	1,900	(± 540)	9.2	(± 2.8)
	Other	3,080	(± 1,110)	14.8	(± 5.1)

Exhibit D-2 (cont'd)

Estimated Number and Percent of Community Water System Wells Belonging to Counties with High Vulnerability

Item	Questionnaire Item	Estimates for CWS Wells in High Vulnerability Counties			
		Number	(95% C.I.)	Percent	(95% C.I.)
II.6	Age of well:				
CWS	< 5 years	1,150	(± 410)	5.5	(± 2.1)
Main	5 to 10 years	3,460	(± 1,440)	16.6	(± 6.7)
A.1	11 to 20 years	7,370	(± 1,800)	35.5	(± 8.1)
	> 20 years	6,020	(± 1,110)	29.0	(± 4.9)
	Don't know	2,790	(± 1,260)	13.4	(± 6.3)
II.7	Well redrilled:				
CWS	Yes	870	(± 630)	4.2	(± 3.0)
Main	No	19,000	(± 1,410)	91.4	(± 5.1)
A.2	Don't know	910	(± 950)*	4.4	(± 4.6)*
II.8	Well depth:				
CWS	< 20 feet	260	(± 510)*	1.2	(± 2.5)*
Main	20 to 50 feet	540	(± 710)*	2.6	(± 3.4)*
A.5	51 to 100 feet	4,270	(± 1,330)	20.5	(± 6.2)
	101 to 200 feet	4,530	(± 1,340)	21.8	(± 6.7)
	201 to 500 feet	6,200	(± 780)	29.8	(± 3.6)
	> 500 feet	3,870	(± 840)	18.6	(± 3.8)
	Don't know	1,130	(± 580)	5.4	(± 2.9)
II.9	Well casing information:				
CWS	Well cased	20,600	(± 1,120)*	99.0	(± 1.4)*
Main	Well not cased	110	(± 210)*	0.5	(± 1.0)*
A.7	Don't know casing	100	(± 200)*	0.5	(± 1.0)*
CWS	Cased to total depth	8,070	(± 1,460)	39.2	(± 7.5)
Main	Cased < total depth	9,550	(± 1,700)	46.4	(± 6.7)
A.11	Don't know casing depth	2,970	(± 1,310)	14.4	(± 6.5)
CWS	Screens in casing	10,500	(± 1,160)	50.9	(± 4.5)
Main	No screens in casing	6,730	(± 1,840)	32.7	(± 7.9)
A.13	Don't know screening	3,380	(± 1,380)	16.4	(± 7.3)
CWS	Well grouted	14,700	(± 2,060)	71.7	(± 7.7)
Main	Well not grouted	1,950	(± 750)	9.5	(± 3.8)
A.18	Don't know grouting	3,940	(± 1,070)	19.2	(± 5.5)

Exhibit D-2 (cont'd)

Estimated Number and Percent of Community Water System Wells Belonging to Counties with High Vulnerability

Item	Questionnaire Item	Estimates for CWS Wells in High Vulnerability Counties			
		Number	(95% C.I.)	Percent	(95% C.I.)
II.10	Well capped at ground surface:				
CWS	Well capped	16,600	(± 1,170)	80.0	(± 4.9)
MAin	Well not capped	4,050	(± 1,050)	19.5	(± 4.7)
A.21	Don't know if capped	110	(± 190)*	0.5	(± 0.9)*
II.11	Distance from the ground surface to the water surface in the well:				
CWS	< 20 feet	4,900	(± 1,620)	23.5	(± 7.6)
Main	20 to 50 feet	5,230	(± 1,230)	25.2	(± 5.6)
A.23	51 to 100 feet	2,650	(± 960)	12.8	(± 4.3)
	101 to 200 feet	1,380	(± 660)	6.6	(± 3.1)
	201 to 500 feet	370	(± 430)*	1.8	(± 2.0)*
	> 500 feet	0	N/A	0.0	N/A
	Don't know	6,280	(± 1,470)	30.2	(± 7.9)
II.12	Aquifer:				
CWS	Confined	9,170	(± 1,650)	44.1	(± 7.8)
Main	Unconfined	6,860	(± 1,860)	33.0	(± 7.8)
A.25	Don't know	5,280	(± 1,590)	25.4	(± 8.2)
II.13	Abandoned or non-operating wells within 500 feet of the well:				
CWS	Yes	5,330	(± 1,630)	25.6	(± 7.9)
Main	No	14,300	(± 1,940)	65.8	(± 8.1)
A.37	Don't know	1,210	(± 670)	5.8	(± 3.2)
II.14	Non-farm pesticides used in the last 3 years:				
CWS	Non-farm pesticides used	5,450	(± 1,450)	26.2	(± 6.2)
Main	Not used	14,600	(± 1,190)	70.3	(± 6.2)
B.1	Don't know whether used	740	(± 590)	3.5	(± 2.9)
CWS	Used < 100 feet from well	3,710	(± 1,330)	68.1	(± 14.6)
Main	Used ≥ 100 feet from well	1,560	(± 890)	28.6	(± 14.8)
B.3	Don't know distance	180	(± 100)	3.3	(± 1.9)

Exhibit D-2 (cont'd)

Estimated Number and Percent of Community Water System Wells Belonging to Counties with High Vulnerability

Item	Questionnaire Item	Estimates for CWS Wells in High Vulnerability Counties			
		Number	(95% C.I.)	Percent	(95% C.I.)
II.15	Non-farm pesticides stored for				
CWS	more than 1 month in the last 3				
Main	years:				
B.4	Non-farm pesticides stored	1,380	(± 1,370)	6.6	(± 6.5)
	Not stored	19,000	(± 1,570)	91.4	(± 6.3)
	Don't know whether stored	420	(± 390)	2.0	(± 1.9)
CWS	Closest Storage < 100 feet	400	(± 580)*	29.1	(±34.1)*
Main	Closest Storage ≥ 100 feet	960	(± 1,170)*	70.9	(±34.1)*
B.5	Don't know distance	0	N/A	0.0	N/A
II.16	Non-farm pesticide container				
CWS	disposal in the last 3 years:				
Main	Containers disposed	0	N/A	0.0	N/A
B.6	No disposal	20,300	(± 1,240)	97.5	(± 2.2)
	Don't know	520	(± 440)	2.5	(± 2.2)
II.17	Accidental spill of non-farm				
CWS	pesticide in the last 3 years:				
Main	Non-farm pesticides spilled	0	N/A	0.0	N/A
B.8	No spill	20,600	(± 970)*	98.9	(± 1.6)*
	Don't know	240	(± 340)*	1.2	(± 1.6)*
II.18	Property farmed in the last 5				
CWS	years:				
Main	Yes	690	(± 490)	3.3	(± 2.3)
C.1	No	19,800	(± 970)	95.0	(± 2.6)
	Don't know	360	(± 230)	1.7	(± 1.1)
CWS	Pesticides used	390	(± 520)*	56.4	(±33.2)*
Main	Not used	200	(± 250)*	28.9	(±39.9)*
C.2	Don't know whether used	100	(± 200)*	14.7	(±30.0)*
II.19	Farm pesticides stored for more				
CWS	than 1 month in the last 5 years:				
Main	Farm pesticides stored	260	(± 370)*	1.3	(± 1.8)*
C.5	Not stored	20,100	(± 1,240)*	96.8	(± 4.0)*
	Don't know whether stored	410	(± 560)*	2.0	(± 2.7)*

Exhibit D-2 (cont'd)

Estimated Number and Percent of Community Water System Wells Belonging to Counties with High Vulnerability

Item	Questionnaire Item	Estimates for CWS Wells in High Vulnerability Counties			
		Number	(95% C.I.)	Percent (95% C.I.)	
II.20 CWS Main C.7	Farm pesticide container disposal on the property in the last 5 years:				
	Containers disposed	0	N/A	0.0	N/A
	No disposal	20,200	(± 1,120)	97.1	(± 2.7)
	Don't know	610	(± 560)	2.9	(± 2.7)
II.21 CWS Main C.9	Accidental spill of farm pesticides on the property in the last 5 years:				
	Farm pesticides spilled	150	(± 300)*	0.7	(± 1.4)*
	No spill	19,900	(± 1,220)	95.9	(± 3.2)
	Don't know whether spill	710	(± 590)	3.4	(± 2.9)
II.22 CWS LAQ #1	Crops farmed within 1/2 mile of well in the last 3 years:				
	Yes	8,250	(± 980)	39.6	(± 3.6)
	No	11,300	(± 740)	54.5	(± 4.5)
	Don't know	1,220	(± 690)	5.9	(± 3.2)
II.23 CWS LAQ #3	Land used for pasture within 1/2 mile of well in the last 3 years:				
	Yes	4,090	(± 600)	19.7	(± 2.4)
	No	14,700	(± 1,180)	70.7	(± 5.4)
	Don't know	2,010	(± 940)	9.7	(± 4.5)
CWS LAQ #4	Pesticides Used	2,410	(± 820)	58.9	(± 19.3)
	Not used	1,680	(± 860)	41.1	(± 19.3)
	Don't know	0	N/A	0.0	N/A
II.24 CWS LAQ #5	Major non-agricultural pesticide application within 1/2 mile of well in the last 3 years:				
	Yes	5,870	(± 1,170)	28.2	(± 5.6)
	No	8,770	(± 1,500)	42.2	(± 7.4)
	Don't know	6,170	(± 1,890)	29.6	(± 8.4)

Exhibit D-2 (cont'd)

Estimated Number and Percent of Community Water System Wells Belonging to Counties with High Vulnerability

Item	Questionnaire Item	Estimates for CWS Wells in High Vulnerability Counties			
		Number	(95% C.I.)	Percent	(95% C.I.)
II.25 CWS LAQ #7	Accidental spill of any pesticide within 1/2 mile of well in the last 3 years:				
	Yes	95	(± 190)*	0.5	(± 0.9)*
	No	14,100	(± 1,060)	68.0	(± 5.2)
	Don't know	6,560	(± 1,390)	31.5	(± 5.9)
II.26 CWS LAQ #9	Accidental spill of any hazardous chemical within 1/2 mile of well in the last 3 years:				
	Yes	600	(± 400)	2.9	(± 1.9)
	No	12,700	(± 1,960)	60.9	(± 9.0)
	Don't know	7,540	(± 1,800)	36.3	(± 8.6)
II.27 CWS LAQ #11j	Golf course within 1/2 mile of well:				
	Yes	2,190	(± 840)	10.5	(± 3.9)
	No	18,200	(± 1,020)	87.6	(± 4.3)
	Don't know	390	(± 290)	1.9	(± 1.4)
II.28 CWS LAQ #2	River, canal, bay, spring, pond, etc. within 1/2 mile of well:				
	Yes	17,500	(± 1,050)	84.2	(± 4.7)
	No	1,920	(± 630)	9.3	(± 2.9)
	Don't know	1,370	(± 420)	6.6	(± 2.0)
II.29 CWS LAQ #13	Irrigation within 1/2 mile of well:				
	Yes	7,560	(± 1,580)	36.4	(± 7.0)
	No	11,500	(± 1,690)	55.2	(± 7.9)
	Don't know	1,760	(± 690)	8.4	(± 3.4)

* For particular responses to questionnaire items where the percent is extreme (i.e., near 0.0% or 100.0% and the sample size is relatively small), the 95% confidence intervals should be treated with caution. For further details see Section B6.4 of Appendix B.

N/A For particular responses to questionnaire items where the percent is equal to 0.0% or 100.0%, traditional 95% confidence intervals based solely on sampling error are not applicable. For further details see Section B6.4 of Appendix B.

Exhibit D-3

Estimated Number and Percent of Rural Domestic Wells in the United States

Item	Questionnaire Item	National Estimates for Rural Domestic Wells			
		Number	(95% C.I.)	Percent	(95% C.I.)
I.1 DWS TLI #6	Septic system on the property:				
	Septic tank	9,730,000	(± 355,000)	92.6	(± 3.4)
	Septic field	9,050,000	(± 470,000)	86.1	(± 4.5)
	Cesspool	853,000	(± 347,000)	8.1	(± 3.3)
I.2 DWS WOR #1	Topographic setting at well:				
	Hilltop	1,750,000	(± 468,000)	16.7	(± 4.5)
	Hillside	3,520,000	(± 611,000)	33.5	(± 5.8)
	Flat valley	3,640,000	(± 793,000)	34.6	(± 7.6)
	Depression	99,300	(± 108,000)*	1.0	(± 1.0)*
	Plateau	298,000	(± 206,000)	2.8	(± 2.0)
	Other	1,190,000	(± 493,000)	11.4	(± 4.7)
	Don't know	0	N/A	0.0	N/A
I.3 DWS WOR #4	Description of land area within 300 feet of well:				
	Roofed	222,000	(± 202,000)	2.1	(± 1.9)
	Paved	0	N/A	0.0	N/A
	Graveled	69,700	(± 94,000)*	0.7	(± 0.9)*
	Exposed or vegetated soil	9,570,000	(± 523,000)	91.1	(± 5.0)
	Other	646,000	(± 475,000)	6.2	(± 4.5)
I.4 DWS WOR #3	Well protection at surface:				
	Well house or shed	3,240,000	(± 550,000)	30.9	(± 5.2)
	Concrete pad	2,170,000	(± 539,000)	20.6	(± 5.1)
	Covered pit	1,350,000	(± 522,000)	12.9	(± 5.0)
	Other	5,570,000	(± 672,000)	53.0	(± 6.4)
I.5 DWS Main D.3	Age of well:				
	< 5 years	1,640,000	(± 389,000)	15.6	(± 3.7)
	5 to 10 years	1,710,000	(± 420,000)	16.3	(± 4.0)
	11 to 20 years	3,070,000	(± 450,000)	29.3	(± 4.3)
	> 20 years	2,520,000	(± 501,000)	24.0	(± 4.8)
	Don't know	1,570,000	(± 398,000)	14.9	(± 3.8)

Exhibit D-3 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in the United States

Item	Questionnaire Item	National Estimates for Rural Domestic Wells			
		Number	(95% C.I.)	Percent (95% C.I.)	
I.6	Well redrilled:				
DWS	Yes	534,000	(± 201,000)	5.1	(± 1.9)
Main	No	9,210,000	(± 403,000)	87.7	(± 3.8)
D.4	Don't know	764,000	(± 336,000)	7.3	(± 3.2)
I.7	Well depth:				
DWS	< 20 feet	385,000	(± 226,000)	3.7	(± 2.2)
Main	20 to 50 feet	1,160,000	(± 306,000)	11.0	(± 2.9)
D.6	51 to 100 feet	2,170,000	(± 335,000)	20.7	(± 3.2)
	101 to 200 feet	2,860,000	(± 475,000)	27.2	(± 4.5)
	201 to 500 feet	1,930,000	(± 398,000)	18.4	(± 3.8)
	> 500 feet	424,000	(± 340,000)	4.0	(± 3.2)
	Don't know	1,580,000	(± 361,000)	15.1	(± 3.4)
I.8	Well casing information:				
DWS	Well cased	9,010,000	(± 390,000)	85.8	(± 3.7)
Main	Not cased	491,000	(± 246,000)	4.7	(± 2.3)
D.8	Don't know casing	1,000,000	(± 316,000)	9.6	(± 3.0)
DWS	Cased to total depth	4,280,000	(± 604,000)	47.5	(± 6.4)
Main	Cased < total depth	2,990,000	(± 490,000)	33.2	(± 5.1)
D.10	Don't know casing depth	1,740,000	(± 344,000)	19.3	(± 3.8)
I.9	Well closed at ground surface:				
DWS	Yes	8,380,000	(± 544,000)	79.8	(± 5.2)
WOR	No	1,190,000	(± 486,000)	11.3	(± 4.6)
#2	Don't know	940,000	(± 385,000)	8.9	(± 3.7)
I.10	Aquifer:				
DWS	Single	2,750,000	(± 474,000)	26.1	(± 4.5)
Main	Double	4,390,000	(± 563,000)	41.7	(± 5.4)
D.17	Don't know	3,380,000	(± 552,000)	32.1	(± 5.3)

Exhibit D-3 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in the United States

Item	Questionnaire Item	National Estimates for Rural Domestic Wells			
		Number	(95% C.I.)	Percent (95% C.I.)	
I.11 DWS Main B.14	Non-operating wells within 500 feet of the well:				
	Yes	2,950,000	(± 490,000)	28.1	(± 4.7)
	No	7,000,000	(± 517,000)	66.6	(± 4.9)
	Don't know	559,000	(± 259,000)	5.3	(± 2.5)
I.12 DWS Main B.1	Non-farm pesticides used in the last 3 years:				
	Used inside house	7,950,000	(± 539,000)	75.7	(± 5.1)
	Not used inside house	2,540,000	(± 537,000)	24.1	(± 5.1)
	Don't know	18,200	(± 37,100)*	0.2	(± 0.4)*
I.13 DWS Main B.2	Non-farm pesticides used in last 3 years:				
	Used on lawn	4,200,000	(± 675,000)	40.0	(± 6.4)
	Not used on lawn	6,270,000	(± 662,000)	59.7	(± 6.3)
	Don't know	35,700	(± 57,500)*	0.3	(± 0.6)*
I.14 DWS Main B.3	Non-farm pesticides used in last 3 years:				
	Used in garden	4,400,000	(± 461,000)	41.9	(± 4.4)
	Not used in garden	6,060,000	(± 471.000)	57.7	(± 4.5)
	Don't know	44,800	(± 67,800)*	0.4	(± 0.6)*
I.15 DWS Main B.4	Non-farm pesticides stored for more than 1 month in the last 3 years:				
	Non-farm pesticides stored	7,120,000	(± 613,000)	67.7	(± 5.8)
	Not stored	3,380,000	(± 614,000)	32.2	(± 5.8)
	Don't know whether stored	9,110	(± 18,500)*	0.1	(± 0.2)*
DWS Main B.5	Stored < 100 feet from well	5,120,000	(± 556,000)	72.0	(± 4.5)
	Stored ≥ 100 feet from well	1,890,000	(± 352,000)	26.6	(± 4.4)
	Don't know where stored	103,000	(± 103,000)*	1.4	(± 1.5)*

Exhibit D-3 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in the United States

Item	Questionnaire Item	National Estimates for Rural Domestic Wells			
		Number	(95% C.I.)	Percent	(95% C.I.)
I.16 DWS Main B.6	Non-farm pesticide container disposal in the last 3 years:				
	Containers disposed	642,000	(± 247,000)	6.1	(± 2.4)
	No disposal	9,860,000	(± 251,000)	93.8	(± 2.4)
	Don't know	9,110	(± 18,500)*	0.1	(± 0.2)*
DWS Main B.7	< 100 feet from well	285,000	(± 144,000)	44.4	(± 18.5)
	≥ 100 feet from well	357,000	(± 190,000)	55.6	(± 18.5)
	Don't know how far	0	N/A	0.0	N/A
I.17 DWS Main B.17 and B.18	Property farmed:†				
	Yes	1,230,000		11.7	
	No	9,280,000		88.3	
DWS Main C.6	Pesticides used for farming in the last 5 years:	1,020,000	(± 120,000)	83.6	(± 8.7)
	Pesticides used	200,000	(± 105,000)	16.4	(± 8.7)
	Not used	0	N/A	0.0	N/A
	Don't know whether used				
I.18 DWS Main C.11 and B.20	Farm pesticides stored for more than 1 month in the last 5 years:				
	Farm pesticides stored	473,000	(± 153,000)	4.5	(± 1.4)
	Not stored	10,000,000	(± 172,000)	95.2	(± 1.6)
	Don't know whether stored	34,900	(± 40,800)*	0.3	(± 0.4)*

Exhibit D-3 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in the United States

Item	Questionnaire Item	National Estimates for Rural Domestic Wells			
		Number	(95% C.I.)	Percent	(95% C.I.)
I.19 DWS Main C.14 and B.22	Farm pesticide container disposal in the last 5 years:				
	Containers disposed	337,000	(± 138,000)	24.0	(± 9.6)
	No disposal	1,070,000	(± 167,000)	76.0	(± 9.6)
	Don't know	0	N/A	0.0	N/A
DWS Main C.16 and B.23	< 100 feet from well	22,500	(± 26,100)	6.7	(± 8.3)
	≥ 100 feet from well	311,000	(± 141,000)	92.2	(± 8.6)
	Don't know how far	3,650	(± 5,520)*	1.1	(± 1.7)*
I.20 DWS Main C.17 and B.24	Accidental spill of farm pesticide in the last 5 years:				
	Farm pesticides spilled	33,700	(± 46,300)*	2.4	(± 3.3)*
	No spill	1,370,000	(± 139,000)	97.6	(± 3.3)
	Don't know whether spilled	0	N/A	0.0	N/A
I.21 DWS LAQ #1	Crops farmed within 1/2 mile of well in the last 3 years:				
	Yes	6,950,000	(± 800,000)	66.2	(± 7.6)
	No	3,300,000	(± 753,000)	31.4	(± 7.2)
	Don't know	258,000	(± 213,000)	2.5	(± 2.0)
I.22 DWS LAQ #3	Pasture land within 1/2 mile of well in the last 3 years:				
	Yes	6,870,000	(± 788,000)	65.4	(± 7.5)
	No	3,430,000	(± 778,000)	32.7	(± 7.4)
	Don't know	203,000	(± 274,000)*	1.9	(± 2.6)*

Exhibit D-3 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in the United States

Item	Questionnaire Item	National Estimates for Rural Domestic Wells			
		Number	(95% C.I.)	Percent	(95% C.I.)
I.23 DWS LAQ #4 (I.22 sub-item)	Pesticides used on pasture land within 1/2 mile of well in the last 3 years:				
	Yes	2,820,000	(± 736,000)	41.1	(± 9.6)
	No	4,050,000	(± 799,000)	58.9	(± 9.6)
	Don't know	0	N/A	0.0	N/A
I.24 DWS LAQ #5	Major non-agricultural pesticide application within 1/2 mile of well in the last 3 years:				
	Yes	1,460,000	(± 500,000)	13.9	(± 4.8)
	No	8,580,000	(± 559,000)	81.6	(± 5.3)
	Don't know	474,000	(± 322,000)	4.5	(± 3.1)
I.25 DWS LAQ #7	Accidental spill of any pesticide within 1/2 mile of well in the last 3 years:				
	Yes	10,100	(± 14,500)*	0.1	(± 0.1)*
	No	1,010,000	(± 383,000)*	96.5	(± 3.6)*
	Don't know	362,000	(± 382,000)*	3.5	(± 3.6)*
I.26 DWS LAQ #9	Accidental spill of any hazardous chemical within 1/2 mile of well in the last 3 years:				
	Yes	17,200	(± 28,200)*	0.2	(± 0.3)*
	No	10,100,000	(± 377,000)	95.7	(± 3.6)
	Don't know	431,000	(± 378,000)	4.1	(± 3.6)
I.27 DWS LAQ #11j	Golf course within 1/2 mile of well:				
	Yes	523,000	(± 259,000)	5.0	(± 2.5)
	No	9,820,000	(± 327,000)	93.5	(± 3.1)
	Don't know	165,000	(± 230,000)*	1.6	(± 2.2)*

Exhibit D-3 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in the United States

Item	Questionnaire Item	National Estimates for Rural Domestic Wells			
		Number	(95% C.I.)	Percent	(95% C.I.)
I.28 DWS LAQ #12	River, canal, bay, spring, pond, etc. within 1/2 mile of well:				
	Yes	9,860,000	(± 363,000)	93.8	(± 3.5)
	No	567,000	(± 350,000)	5.4	(± 3.3)
	Don't know	82,000	(± 98,000)*	0.8	(± 0.9)*
I.29 DWS LAQ #13	Irrigation within 1/2 mile of well:				
	Yes	1,910,000	(± 564,000)	18.1	(± 5.4)
	No	8,550,000	(± 582,000)	81.4	(± 5.5)
	Don't know	49,500	(± 60,300)*	0.5	(± 0.6)*

* For particular responses to questionnaire items where the percent is extreme (i.e., near 0.0% or 100.0% and the sample size is relatively small), the 95% confidence intervals should be treated with caution. For further details see Section B6.4 of Appendix B.

N/A For particular responses to questionnaire items where the percent is equal to 0.0% or 100.0%, traditional 95% confidence intervals based solely on sampling error are not applicable. For further details see Section B6.4 of Appendix B.

† The total number of rural domestic wells (10,509,373) and the subpopulation corresponding to rural domestic wells on farm land (1,219,841) were estimated from the 1987 American Housing Survey administered by the U.S. Bureau of the Census. They are treated as constants in the Survey, and hence, have no associated confidence intervals.

Exhibit D-4

Estimated Number and Percent of Rural Domestic Wells in Counties with High Pesticide Use

Item	Questionnaire Item	Estimates for Rural Domestic Wells in Counties with High Pesticide Use			
		Number	(95% C.I.)	Percent	(95% C.I.)
II.1 DWS TLI #6	Septic system on the property:				
	Septic tank	1,030,000	(± 273,000)	89.2	(± 10.3)
	Septic field	943,000	(± 277,000)	81.6	(± 8.0)
	Cesspool	96,400	(± 84,300)	8.3	(± 6.7)
II.2 DWS WOR #1	Topographic setting at well:				
	Hilltop	181,000	(± 122,000)	15.6	(± 9.2)
	Hillside	155,000	(± 130,000)	13.5	(± 9.8)
	Flat valley	568,000	(± 294,000)	49.2	(± 23.8)
	Depression	14,600	(± 18,500)*	1.3	(± 1.6)*
	Plateau	68,000	(± 80,700)*	5.9	(± 6.5)*
	Other	169,000	(± 163,000)	14.6	(± 14.2)
	Don't know	0	N/A	0.0	N/A
II.3 DWS WOR #4	Description of land area within 300 feet of well:				
	Roofed	8,190	(± 11,700)*	0.7	(± 1.0)*
	Paved	0	N/A	0.0	N/A
	Graveled	4,880	(± 9,720)*	0.4	(± 0.9)*
	Exposed or vegetated soil	983,000	(± 321,000)*	85.0	(± 24.6)*
	Other	160,000	(± 291,000)*	13.9	(± 24.7)*
II.4 DWS WOR #3	Well protection at surface:				
	Well house or shed	183,000	(± 136,000)	15.8	(± 12.9)
	Concrete pad	65,100	(± 57,400)	5.6	(± 5.1)
	Covered pit	198,000	(± 117,000)	17.2	(± 10.2)
	Other	732,000	(± 356,000)	63.3	(± 18.8)
II.5 DWS Main D.3	Age of well:				
	< 5 years	140,000	(± 79,200)	12.1	(± 5.9)
	5 to 10 years	141,000	(± 64,300)	12.2	(± 4.7)
	11 to 20 years	385,000	(± 174,000)	33.3	(± 9.0)
	> 20 years	275,000	(± 110,000)	23.7	(± 10.0)
	Don't know	216,000	(± 90,600)	18.7	(± 5.0)

Exhibit D-4 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in Counties with High Pesticide Use

Item	Questionnaire Item	Estimates for Rural Domestic Wells in Counties with High Pesticide Use			
		Number	(95% C.I.)	Percent	(95% C.I.)
II.6	Well redrilled:				
DWS	Yes	54,800	(± 29,700)	4.7	(± 2.6)
Main	No	1,020,000	(± 300,000)	88.3	(± 4.6)
D.4	Don't know	81,000	(± 53,500)	7.0	(± 4.2)
II.7	Well depth:				
DWS	< 20 feet	25,300	(± 28,400)*	2.2	(± 2.4)*
Main	20 to 50 feet	181,000	(± 109,000)	15.7	(± 9.1)
D.6	51 to 100 feet	190,000	(± 88,700)	16.4	(± 6.9)
	101 to 200 feet	277,000	(± 108,000)	24.0	(± 7.3)
	201 to 500 feet	243,000	(± 171,000)	21.1	(± 12.7)
	> 500 feet	29,100	(± 28,100)*	2.5	(± 2.5)*
	Don't know	211,000	(± 131,000)	18.2	(± 9.7)
II.8	Well casing information:				
DWS	Well cased	1,010,000	(± 303,000)	87.5	(± 8.0)
Main	Not cased	30,300	(± 26,600)	2.6	(± 2.4)
D.8	Don't know casing	114,000	(± 90,800)	9.9	(± 7.3)
DWS	Cased to total depth	613,000	(± 195,000)	60.6	(± 14.3)
Main	Cased < total depth	154,000	(± 128,000)	15.2	(± 10.7)
D.10	Don't know casing depth	244,000	(± 113,000)	24.2	(± 8.2)
II.9	Well closed at ground surface:				
DWS	Yes	1,010,000	(± 321,000)	87.0	(± 9.7)
WOR	No	57,400	(± 77,100)*	5.0	(± 6.8)*
#2	Don't know	93,100	(± 76,100)	8.1	(± 6.3)
II.10	Aquifer:				
DWS	Single	348,000	(± 145,000)	30.1	(± 8.4)
Main	Double	407,000	(± 126,000)	35.2	(± 7.5)
D.17	Don't know	401,000	(± 175,000)	34.7	(± 11.1)

Exhibit D-4 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in Counties with High Pesticide Use

Item	Questionnaire Item	Estimates for Rural Domestic Wells in Counties with High Pesticide Use			
		Number	(95% C.I.)	Percent	(95% C.I.)
II.11 DWS Main B.14	Non-operating wells within 500 feet of the well:				
	Yes	269,000	(± 113,000)	23.3	(± 7.9)
	No	801,000	(± 242,000)	69.3	(± 8.2)
	Don't know	85,900	(± 89,200)*	7.4	(± 7.3)*
II.12 DWS Main B.1	Non-farm pesticides used in the last 3 years:				
	Used inside house	946,000	(± 277,000)	81.8	(± 6.5)
	Not used inside house	210,000	(± 95,000)	18.2	(± 6.5)
	Don't know	0	N/A	0.0	N/A
II.13 DWS Main B.2	Non-farm pesticides used in the last 3 years:				
	Used on lawn	511,000	(± 186,000)	44.2	(± 9.3)
	Not used on lawn	645,000	(± 204,000)	55.8	(± 9.3)
	Don't know	0	N/A	0.0	N/A
II.14 DWS Main B.3	Non-farm pesticides used in the last 3 years:				
	Used in garden	494,000	(± 156,000)	42.7	(± 8.7)
	Not used in garden	663,000	(± 228,000)	57.3	(± 8.7)
	Don't know	0	N/A	0.0	N/A
II.15 DWS Main B.4	Non-farm pesticides stored for more than 1 month in the last 3 years:				
	Non-farm pesticides stored	829,000	(± 274,000)	71.7	(± 11.0)
	Not stored	328,000	(± 150,000)	28.3	(± 11.0)
	Don't know whether stored	0	N/A	0.0	N/A
DWS Main B.5	Stored < 100 feet from well	526,000	(± 190,000)	63.5	(± 12.5)
	Stored ≥ 100 feet from well	295,000	(± 152,000)	35.7	(± 12.7)
	Don't know where stored	7,190	(± 14,400)*	0.9	(± 1.7)*

Exhibit D-4 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in Counties with High Pesticide Use

Item	Questionnaire Item	Estimates for Rural Domestic Wells in Counties with High Pesticide Use			
		Number	(95% C.I.)	Percent	(95% C.I.)
II.16 DWS Main B.6	Non-farm pesticide container disposal in the last 3 years:				
	Containers disposed	173,000	(± 94,000)	14.9	(± 7.4)
	No disposal	984,000	(± 298,000)	85.1	(± 7.4)
	Don't know	0	N/A	0.0	N/A
DWS Main B.7	< 100 feet from well	63,400	(± 60,000)	36.8	(± 25.3)
	≥ 100 feet from well	109,000	(± 59,700)	63.2	(± 25.3)
	Don't know how far	0	N/A	0.0	N/A
II.17 DWS Main B.17 and B.18	Property farmed:				
	Yes	287,000	(± 97,600)	24.80	(± 9.80)
	No	870,000	(± 322,000)	75.20	(± 9.80)
DWS Main C.6	Pesticides used for farming in the last 5 years:				
	Pesticides used	251,000	(± 95,100)	87.4	(± 10.8)
	Not used	36,100	(± 30,600)	12.6	(± 10.8)
	Don't know whether used	0	N/A	0.0	N/A
II.18 DWS Main C.11 and B.20	Farm pesticides stored for more than 1 month in the last 5 years:				
	Farm pesticides stored	71,900	(± 41,600)	6.2	(± 3.7)
	Not stored	1,080,000	(± 323,000)	93.8	(± 3.7)
	Don't know whether stored	0	N/A	0.0	N/A

Exhibit D-4 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in Counties with High Pesticide Use

Item	Questionnaire Item	Estimates for Rural Domestic Wells in Counties with High Pesticide Use			
		Number	(95% C.I.)	Percent (95% C.I.)	
II.19 DWS Main C.14 and B.22	Farm pesticide container disposal in the last 5 years:				
	Containers disposed	96,500	(± 44,900)	31.7	(± 7.9)
	No disposal	208,000	(± 72,400)	68.3	(± 7.9)
	Don't know	0	N/A	0.0	N/A
				11.8	(±15.2)*
DWS Main C.16 and B.23	< 100 feet from well	11,400	(± 14,300)*	84.4	(±16.2)*
	≥ 100 feet from well	81,500	(± 45,300)*	3.8	(± 6.0)*
	Don't know how far	3,650	(± 5,520)*		
II.20 DWS Main C.17 and B.24	Accidental spill of farm pesticide in the last 5 years:				
	Farm pesticides spilled	13,600	(± 20,100)*	4.5	(± 6.6)*
	No spill	291,000	(± 105,000)*	95.5	(± 6.6)*
	Don't know whether spilled	0	N/A	0.0	N/A
II.21 DWS LAQ #1	Crops farmed within 1/2 mile of well in the last 3 years:				
	Yes	1,040,000	(± 308,000)	89.8	(± 8.1)
	No	116,000	(± 97,100)	10.0	(± 8.1)
	Don't know	2,140	(± 4,290)*	0.2	(± 0.4)*
II.22 DWS LAQ #3	Pasture land within 1/2 mile of well in the last 3 years:				
	Yes	664,000	(± 185,000)	57.4	(±14.0)
	No	469,000	(± 251,000)	40.6	(±14.5)
	Don't know	22,800	(± 45,700)*	2.0	(± 3.9)*

Exhibit D-4 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in Counties with High Pesticide Use

Item	Questionnaire Item	Estimates for Rural Domestic Wells in Counties with High Pesticide Use			
		Number	(95% C.I.)	Percent	(95% C.I.)
II.23 DWS LAQ #4 (II.22 sub-item)	Pesticides used on pasture land within 1/2 mile of well in the last 3 years:				
	Yes	353,000	(± 131,000)	53.2	(± 20.0)
	No	311,000	(± 182,000)	46.9	(± 20.0)
	Don't know	0	N/A	0.0	N/A
II.24 DWS LAQ #5	Major non-agricultural pesticide application within 1/2 mile of well in the last 3 years:				
	Yes	340,000	(± 205,000)	29.4	(± 18.9)
	No	808,000	(± 366,000)	69.9	(± 18.8)
	Don't know	8,700	(± 17,500)*	0.8	(± 1.5)*
II.25 DWS LAQ #7	Accidental spill of any pesticide within 1/2 mile of well in the last 3 years:				
	Yes	4,140	(± 8,250)*	0.4	(± 0.7)*
	No	1,130,000	(± 325,000)*	97.9	(± 4.2)*
	Don't know	20,300	(± 40,900)*	1.8	(± 3.5)*
II.26 DWS LAQ #9	Accidental spill of any hazardous chemical within 1/2 mile of well in the last 3 years:				
	Yes	3,690	(± 7,300)*	0.3	(± 0.6)*
	No	1,140,000	(± 325,000)*	98.9	(± 1.6)*
	Don't know	8,700	(± 17,500)*	0.8	(± 1.5)*
II.27 DWS LAQ #11j	Golf course within 1/2 mile of well:				
	Yes	27,100	(± 32,600)*	2.3	(± 2.7)*
	No	1,130,000	(± 317,000)*	97.7	(± 2.7)*
	Don't know	0	N/A	0.0	N/A

Exhibit D-4 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in Counties with High Pesticide Use

Item	Questionnaire Item	Estimates for Rural Domestic Wells in Counties with High Pesticide Use			
		Number	(95% C.I.)	Percent (95% C.I.)	
II.28 DWS LAQ #12	River, canal, bay, spring, pond, etc. within 1/2 mile of well: Yes No Don't know	 1,080,000 40,900 35,800	 (± 337,000)* (± 42,600)* (± 70,400)*	 93.4 3.5 3.1	 (± 7.3)* (± 3.6)* (± 6.1)*
II.29 DWS LAQ #13	Irrigation within 1/2 mile of well: Yes No Don't know	 234,000 923,000 0	 (± 150,000) (± 318,000) N/A	 20.2 79.8 0.0	 (± 12.8) (± 12.8) N/A

* For particular responses to questionnaire items where the percent is extreme (i.e., near 0.0% or 100.0% and the sample size is relatively small), the 95% confidence intervals should be treated with caution. For further details see Section B8.4 of Appendix B.

N/A For particular responses to questionnaire items where the percent is equal to 0.0% or 100.0%, traditional 95% confidence intervals based soley on sampling error are not applicable. For further details see Section B8.4 of Appendix B.

Exhibit D-5

Estimated Number and Percent of Rural Domestic Wells in Counties with High Vulnerability

Item	Questionnaire Item	Estimates for Rural Domestic Wells in Counties with High Vulnerability			
		Number	(95% C.I.)	Percent	(95% C.I.)
III.1 DWS TLI #6	Septic system on the property:				
	Septic tank	2,810,000	(± 488,000)	97.7	(± 2.0)
	Septic field	2,680,000	(± 443,000)	93.1	(± 6.3)
	Cesspool	196,000	(± 154,000)	6.8	(± 5.5)
III.2 DWS WOR #1	Topographic setting at well:				
	Hilltop	598,000	(± 259,000)	20.8	(± 7.6)
	Hillside	639,000	(± 391,000)	22.2	(± 11.5)
	Flat valley	1,010,000	(± 420,000)	35.0	(± 14.6)
	Depression	25,100	(± 41,300)*	0.9	(± 1.5)*
	Plateau	96,900	(± 124,000)*	3.4	(± 4.3)*
	Other	508,000	(± 356,000)	17.7	(± 13.1)
	Don't Know	0	N/A	0.0	N/A
III.3 DWS WOR #4	Description of land area within 300 feet of well:				
	Roofed	92,700	(± 154,000)*	3.2	(± 5.4)*
	Paved	0	N/A	0.0	N/A
	Graveled	4,880	(± 9,720)*	0.2	(± 0.3)*
	Exposed or vegetated soil	2,560,000	(± 562,000)*	89.1	(± 11.7)*
	Other	217,000	(± 288,000)*	7.5	(± 10.1)*
III.4 DWS WOR #3	Well protection at surface:				
	Well house or shed	1,150,000	(± 385,000)	40.1	(± 13.6)
	Concrete pad	661,000	(± 1,300,000)*	23.0	(± 45.1)*
	Covered pit	502,000	(± 984,000)*	17.5	(± 34.2)*
	Other	1,290,000	(± 2,520,000)*	44.8	(± 87.8)*
III.5 DWS Main D.3	Age of well:				
	< 5 years	560,000	(± 236,000)	19.5	(± 6.9)
	5 to 10 years	493,000	(± 229,000)	17.1	(± 7.6)
	11 to 20 years	803,000	(± 290,000)	28.0	(± 9.6)
	> 20 years	553,000	(± 227,000)	19.3	(± 7.6)
	Don't know	465,000	(± 286,000)	16.2	(± 9.5)

Exhibit D-5 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in Counties with High Vulnerability

Item	Questionnaire Item	Estimates for Rural Domestic Wells in Counties with High Vulnerability			
		Number	(95% C.I.)	Percent	(95% C.I.)
III.6	Well redrilled:				
DWS	Yes	162,000	(± 126,000)	5.6	(± 4.3)
Main	No	2,390,000	(± 466,000)	83.3	(± 10.0)
D.4	Don't know	317,000	(± 270,000)	11.1	(± 9.2)
III.7	Well depth:				
DWS	< 20 feet	129,000	(± 118,000)*	4.5	(± 4.2)*
Main	20 to 50 feet	418,000	(± 180,000)	14.5	(± 5.9)
D.6	51 to 100 feet	449,000	(± 164,000)	15.6	(± 5.8)
	101 to 200 feet	626,000	(± 214,000)	21.8	(± 6.0)
	201 to 500 feet	532,000	(± 249,000)	18.5	(± 7.7)
	> 500 feet	76,700	(± 127,000)*	2.7	(± 4.5)*
	Don't know	643,000	(± 263,000)	22.4	(± 8.0)
III.8	Well casing information:				
DWS	Well cased	2,220,000	(± 435,000)	77.2	(± 7.4)
Main	Not cased	241,000	(± 173,000)	8.4	(± 5.9)
D.8	Don't know casing	414,000	(± 184,000)	14.4	(± 5.9)
DWS	Cased to total depth	1,170,000	(± 385,000)	52.8	(± 14.2)
Main	Cased < total depth	559,000	(± 304,000)	25.2	(± 11.8)
D.10	Don't know casing depth	489,000	(± 174,000)	22.0	(± 8.4)
III.9	Well closed at ground surface:				
DWS	Yes	2,210,000	(± 469,000)	76.8	(± 7.7)
WOR	No	396,000	(± 227,000)	13.8	(± 8.1)
#2	Don't know	268,000	(± 164,000)	9.3	(± 5.5)
III.10	Aquifer:				
DWS	Single	554,000	(± 251,000)	19.3	(± 8.2)
Main	Double	1,370,000	(± 344,000)	47.6	(± 10.5)
D.17	Don't know	953,000	(± 352,000)	33.2	(± 10.0)

Exhibit D-5 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in Counties with High Vulnerability

Item	Questionnaire Item	Estimates for Rural Domestic Wells in Counties with High Vulnerability			
		Number	(95% C.I.)	Percent	(95% C.I.)
III.11 DWS Main B.14	Non-operating wells within 500 feet of the well:				
	Yes	793,000	(± 303,000)	27.6	(± 9.0)
	No	1,880,000	(± 405,000)	65.4	(± 8.6)
	Don't know	201,000	(± 152,000)	7.0	(± 5.5)
III.12 DWS Main B.1	Non-farm pesticides used in the last 3 years:				
	Used inside house	2,280,000	(± 452,000)	79.3	(± 11.4)
	Not used inside house	594,000	(± 357,000)	20.7	(± 11.4)
	Don't know	0	N/A	0.0	N/A
III.13 DWS Main B.2	Non-farm pesticides used in the last 3 years:				
	Used on lawn	1,050,000	(± 434,000)	36.6	(± 14.6)
	Not used on lawn	1,820,000	(± 544,000)	63.4	(± 14.6)
	Don't know	0	N/A	0.0	N/A
III.14 DWS Main B.3	Non-farm pesticides used in the last 3 years:				
	Used in garden	1,260,000	(± 333,000)	43.7	(± 9.5)
	Not used in garden	1,620,000	(± 397,000)	56.3	(± 9.5)
	Don't know	0	N/A	0.0	N/A
III.15 DWS Main B.4	Non-farm pesticides stored for more than 1 month in the last 3 years:				
	Non-farm pesticides stored	1,890,000	(± 422,000)	65.9	(± 11.7)
	Not stored	979,000	(± 399,000)	34.1	(± 11.7)
	Don't know whether stored	0	N/A	0.0	N/A
DWS Main B.5	Stored < 100 feet from well	1,460,000	(± 376,000)	77.3	(± 7.4)
	Stored ≥ 100 feet from well	365,000	(± 147,000)	19.3	(± 6.7)
	Don't know where stored	64,300	(± 90,400)*	3.4	(± 4.9)*

Exhibit D-5 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in Counties with High Vulnerability

Item	Questionnaire Item	Estimates for Rural Domestic Wells in Counties with High Vulnerability			
		Number	(95% C.I.)	Percent	(95% C.I.)
III.16 DWS Main B.6	Non-farm pesticide container disposal in the last 3 years:				
	Containers disposed	81,800	(± 73,100)	2.9	(± 2.6)
	No disposal	2,790,000	(± 503,000)	97.2	(± 2.6)
	Don't know	0	N/A	0.0	N/A
DWS Main B.7	< 100 feet from well	44,600	(± 47,600)	54.5	(±29.7)
	≥ 100 feet from well	37,300	(± 36,900)	45.5	(±29.7)
	Don't know how far	0	N/A	0.0	N/A
III.17 DWS Main B.17 and B.18	Property farmed:				
	Yes	241,000	(± 134,000)	8.4	(± 4.6)
	No	2,630,000	(± 480,000)	91.6	(± 4.6)
DWS Main C.6	Pesticides used for farming in the last 5 years:				
	Pesticides used	147,000	(± 100,000)	61.0	(±25.2)
	Not used	93,800	(± 77,800)	39.0	(±25.2)
	Don't know whether used	0	N/A	0.0	N/A
III.18 DWS Main C.11 and B.20	Farm pesticides stored for more than 1 month in the last 5 years:				
	Farm pesticides stored	93,500	(± 71,000)	3.3	(± 2.5)
	Not stored	2,780,000	(± 483,000)	96.7	(± 2.5)
	Don't know whether stored	0	N/A	0.0	N/A

Exhibit D-5 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in Counties with High Vulnerability

Item	Questionnaire Item	Estimates for Rural Domestic Wells in Counties with High Vulnerability			
		Number	(95% C.I.)	Percent	(95% C.I.)
III.19 DWS Main C.14 and B.22	Farm pesticide container disposal in the last 5 years:				
	Containers disposed	23,100	(± 30,900)	7.7	(± 11.9)
	No disposal	277,000	(± 200,000)	92.3	(± 11.9)
	Don't know	0	N/A	0.0	N/A
DWS Main C.16 and B.23	< 100 feet from well	3,750	(± 7,460)*	16.2	(± 61.0)*
	≥ 100 feet from well	18,200	(± 30,300)*	78.8	(± 74.4)*
	Don't know how far	1,160	(± 2,300)*	5.0	(± 19.0)*
III.20 DWS Main C.17 and B.24	Accidental spill of farm pesticide in the last 5 years:				
	Farm pesticides spilled	0	N/A	0.0	N/A
	No spill	300,000	(± 202,000)	100.0	N/A
	Don't know whether spilled	0	N/A	0.0	N/A
III.21 DWS LAQ #1	Crops farmed within 1/2 mile of well in the last 3 years:				
	Yes	1,750,000	(± 525,000)	60.9	(± 14.2)
	No	1,100,000	(± 434,000)	38.6	(± 14.2)
	Don't know	15,000	(± 29,800)*	0.5	(± 1.0)*
III.22 DWS LAQ #3	Pasture land within 1/2 mile of well in the last 3 years:				
	Yes	1,590,000	(± 530,000)	55.4	(± 14.4)
	No	1,260,000	(± 429,000)	43.9	(± 14.4)
	Don't know	20,200	(± 41,100)*	0.7	(± 1.4)*

Exhibit D-5 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in Counties with High Vulnerability

Item	Questionnaire Item	Estimates for Rural Domestic Wells in Counties with High Vulnerability			
		Number	(95% C.I.)	Percent	(95% C.I.)
III.23 DWS LAQ #4 (III.22 sub-item)	Pesticides used on pasture land within 1/2 mile of well in the last 3 years:				
	Yes	714,000	(± 450,000)	44.9	(±22.9)
	No	878,000	(± 419,000)	55.1	(±22.9)
	Don't know	0	N/A	0.0	N/A
III.24 DWS LAQ #5	Major non-agricultural pesticide application within 1/2 mile of well in the last 3 years:				
	Yes	705,000	(± 301,000)	24.5	(±11.6)
	No	2,110,000	(± 575,000)	73.4	(±11.1)
	Don't know	59,700	(± 69,500)*	2.1	(± 2.4)*
III.25 DWS LAQ #7	Accidental spill of any pesticide within 1/2 mile of well in the last 3 years:				
	Yes	0	N/A	0.0	N/A
	No	2,850,000	(± 486,000)*	99.0	(± 1.4)*
	Don't know	28,100	(± 41,300)*	1.0	(± 1.4)*
III.26 DWS LAQ #9	Accidental spill of any hazardous chemical within 1/2 mile of well in the last 3 years:				
	Yes	0	N/A	0.0	N/A
	No	2,820,000	(± 490,000)*	98.2	(± 3.1)*
	Don't know	52,600	(± 88,000)*	1.8	(± 3.1)*
III.27 DWS LAQ #11j	Golf course within 1/2 mile of well:				
	Yes	180,000	(± 165,000)	6.3	(± 5.6)
	No	2,650,000	(± 477,000)	92.4	(± 5.8)
	Don't know	39,100	(± 79,800)*	1.4	(± 2.8)*

Exhibit D-5 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in Counties with High Vulnerability

Item	Questionnaire Item	Estimates for Rural Domestic Wells in Counties with High Vulnerability			
		Number	(95% C.I.)	Percent	(95% C.I.)
III.28 DWS LAQ #12	River, canal, bay, spring, pond, etc. within 1/2 mile of well:				
	Yes	2,790,000	(± 493,000)	97.0	(± 3.4)
	No	45,400	(± 40,600)	1.6	(± 1.5)
	Don't know	41,500	(± 65,800)*	1.4	(± 2.3)*
III.29 DWS LAQ #13	Irrigation within 1/2 mile of well:				
	Yes	543,000	(± 281,000)	18.9	(± 9.1)
	No	2,320,000	(± 456,000)	80.7	(± 8.9)
	Don't know	11,000	(± 22,300)*	0.4	(± 0.8)*

* For particular responses to questionnaire items where the percent is extreme (i.e., near 0.0% or 100.0% and the sample size is relatively small), the 95% confidence intervals should be treated with caution. For further details see Section B6.4 of Appendix B.

N/A For particular responses to questionnaire items where the percent is equal to 0.0% or 100.0%, traditional 95% confidence intervals based solely on sampling error are not applicable. For further details see Section B6.4 of Appendix B.

Exhibit D-6

Estimated Number and Percent of Rural Domestic Wells in "Cropped and Vulnerable" County Subregions

Item	Questionnaire Item	Estimates for Rural Domestic Wells in "Cropped and Vulnerable" County Subregions			
		Number	(95% C.I.)	Percent (95% C.I.)	
IV.1 DWS TU #6	Septic system on the property:				
	Septic tank	3,370,000	(± 711,000)	91.3	(± 5.9)
	Septic field	3,080,000	(± 672,000)	83.5	(± 7.3)
	Cesspool	224,000	(± 149,000)	6.1	(± 3.9)
IV.2 DWS WOR #1	Topographic setting at well:				
	Hilltop	379,000	(± 222,000)	10.3	(± 5.4)
	Hillside	1,070,000	(± 483,000)	29.0	(± 10.5)
	Flat valley	1,730,000	(± 539,000)	47.0	(± 12.1)
	Depression	1,390	(± 2,780)*	0.0	(± 0.1)*
	Plateau	85,500	(± 101,000)*	2.3	(± 2.8)*
	Other	421,000	(± 273,000)	11.4	(± 7.3)
	Don't know	0	N/A	0.0	N/A
IV.3 DWS WOR #4	Description of land area within 300 feet of well:				
	Roofed	77,700	(± 103,000)*	2.1	(± 2.8)*
	Paved	0	N/A	0.0	N/A
	Graveled	16,700	(± 25,700)*	0.5	(± 0.7)*
	Exposed or vegetated soil	3,530,000	(± 770,000)	95.5	(± 3.5)
	Other	71,700	(± 72,000)*	1.9	(± 1.7)*
IV.4 DWS WOR #3	Well protection at surface:				
	Well house or shed	986,000	(± 402,000)	26.7	(± 9.2)
	Concrete pad	445,000	(± 203,000)	12.0	(± 5.6)
	Covered pit	517,000	(± 271,000)	14.0	(± 6.9)
	Other	2,020,000	(± 655,000)	54.7	(± 12.0)
IV.5 DWS Main D.3	Age of well:				
	< 5 years	409,000	(± 193,000)	11.1	(± 5.2)
	5 to 10 years	590,000	(± 238,000)	16.0	(± 5.1)
	11 to 20 years	1,010,000	(± 273,000)	27.4	(± 5.3)
	> 20 years	918,000	(± 374,000)	24.7	(± 8.6)
	Don't know	764,000	(± 348,000)	20.7	(± 7.7)

Exhibit D-6 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in "Cropped and Vulnerable" County Subregions

Item	Questionnaire Item	Estimates for Rural Domestic Wells in "Cropped and Vulnerable" County Subregions			
		Number	(95% C.I.)	Percent	(95% C.I.)
IV.6	Well redrilled:				
DWS	Yes	133,000	(± 77,600)	3.6	(± 2.0)
Main	No	3,120,000	(± 726,000)	84.4	(± 8.1)
D.4	Don't know	443,000	(± 302,000)	12.0	(± 7.7)
IV.7	Well depth:				
DWS	< 20 feet	39,800	(± 47,300)*	1.1	(± 1.3)*
Main	20 to 50 feet	470,000	(± 196,000)	12.7	(± 4.9)
D.6	51 to 100 feet	984,000	(± 318,000)	26.7	(± 6.4)
	101 to 200 feet	1,040,000	(± 378,000)	28.2	(± 7.6)
	201 to 500 feet	382,000	(± 200,000)	10.4	(± 4.7)
	> 500 feet	23,700	(± 35,000)*	0.6	(± 9.6)*
	Don't know	751,000	(± 270,000)	20.3	(± 6.1)
IV.8	Well casing information:				
DWS	Well cased	3,020,000	(± 766,000)	81.7	(± 7.1)
Main	Not cased	224,000	(± 159,000)	6.1	(± 4.2)
D.8	Don't know casing	454,000	(± 217,000)	12.3	(± 6.0)
DWS	Cased to total depth	1,480,000	(± 427,000)	49.0	(± 10.3)
Main	Cased < total depth	925,000	(± 389,000)	30.7	(± 8.2)
D.10	Don't know casing depth	612,000	(± 246,000)	20.3	(± 6.7)
IV.9	Well closed at ground surface:				
DWS	Yes	2,880,000	(± 687,000)	78.0	(± 10.4)
WOR	No	389,000	(± 326,000)	10.6	(± 8.2)
#2	Don't know	422,000	(± 290,000)	11.4	(± 7.8)
IV.10	Aquifer:				
DWS	Single	883,000	(± 306,000)	23.9	(± 7.1)
Main	Double	1,560,000	(± 529,000)	42.3	(± 9.7)
D.17	Don't know	1,250,000	(± 407,000)	33.8	(± 9.1)

Exhibit D-6 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in "Cropped and Vulnerable" County Subregions

Item	Questionnaire Item	Estimates for Rural Domestic Wells in "Cropped and Vulnerable" County Subregions			
		Number	(95% C.I.)	Percent (95% C.I.)	
IV.11 DWS Main B.14	Non-operating wells within 500 feet of the well:				
	Yes	963,000	(± 363,000)	26.1	(± 8.2)
	No	2,470,000	(± 573,000)	67.0	(± 8.5)
	Don't know	257,000	(± 195,000)	7.0	(± 5.0)
IV.12 DWS Main B.1	Non-farm pesticides used in the last 3 years:				
	Used inside house	2,760,000	(± 686,000)	74.7	(± 9.7)
	Not used inside house	933,000	(± 416,000)	25.3	(± 9.7)
	Don't know	0	N/A	0.0	N/A
IV.13 DWS Main B.2	Non-farm pesticides used in the last 3 years:				
	Pesticide used on lawn	1,410,000	(± 432,000)	38.3	(± 8.5)
	Not used on lawn	2,250,000	(± 590,000)	61.0	(± 8.3)
	Don't know	26,600	(± 54,400)*	0.7	(± 1.5)*
IV.14 DWS Main B.3	Non-farm pesticides used in the last 3 years:				
	Used in garden	1,410,000	(± 352,000)	38.2	(± 6.9)
	Not used in garden	2,250,000	(± 612,000)	61.1	(± 7.1)
	Don't know	26,600	(± 54,500)*	0.7	(± 1.5)*
IV.15 DWS Main B.4	Non-farm pesticides stored for more than 1 month in the last 3 years:				
	Non-farm pesticides stored	2,510,000	(± 571,000)	68.0	(± 6.7)
	Not stored	1,180,000	(± 380,000)	32.0	(± 6.7)
	Don't know whether stored	0	N/A	0.0	N/A
DWS Main B.5	Stored < 100 feet from well	1,880,000	(± 462,000)	74.9	(± 7.2)
	Stored ≥ 100 feet from well	554,000	(± 211,000)	22.1	(± 7.0)
	Don't know where stored	74,800	(± 93,600)*	3.0	(± 3.7)*

Exhibit D-6 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in "Cropped and Vulnerable" County Subregions

Item	Questionnaire Item	Estimates for Rural Domestic Wells in "Cropped and Vulnerable" County Subregions			
		Number	(95% C.I.)	Percent	(95% C.I.)
IV.16 DWS Main B.6	Non-farm pesticide container disposal in the last 3 years:				
	Containers disposed	169,000	(± 165,000)	4.6	(± 4.3)
	No disposal	3,520,000	(± 755,000)	95.4	(± 4.3)
	Don't know	0	N/A	0.0	N/A
DWS Main B.7	< 100 feet from well	32,800	(± 24,800)*	19.4	(±36.3)*
	≥ 100 feet from well	137,000	(± 163,000)*	80.6	(±36.3)*
	Don't know how far	0	N/A	0.0	N/A
IV.17 DWS Main B.17 and B.18	Property farmed:				
	Yes	392,000	(± 119,000)	10.6	(± 2.7)
	No	3,300,000	(± 738,000)	89.4	(± 2.7)
DWS Main C.6	Pesticides used for farming in the last 5 years:				
	Pesticides used	362,000	(± 110,000)	92.4	(± 6.8)
	Not used	29,900	(± 28,500)	7.6	(± 6.8)
	Don't know whether use	0	N/A	0.0	N/A
IV.18 DWS Main C.11 and B.20	Farm pesticides stored for more than 1 month in the last 5 years:				
	Farm pesticides stored	151,000	(± 79,100)	4.1	(± 2.0)
	Not stored	3,530,000	(± 767,000)	95.6	(± 2.0)
	Don't know whether stored	10,000	(± 20,700)*	0.3	(± 0.6)*

Exhibit D-6 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in "Cropped and Vulnerable" County Subregions

Item	Questionnaire Item	Estimates for Rural Domestic Wells in "Cropped and Vulnerable" County Subregions			
		Number	(95% C.I.)	Percent	(95% C.I.)
IV.19 DWS Main C.14 and B.22	Farm pesticide container disposal in the last 5 years:				
	Containers disposed	119,000	(± 74,200)	25.8	(± 12.3)
	No disposal	344,000	(± 107,000)	74.2	(± 12.3)
	Don't know	0	N/A	0.0	N/A
DWS Main C.16 and B.23	< 100 feet from well	11,400	(± 14,300)*	9.5	(± 13.3)*
	≥ 100 feet from well	107,000	(± 73,600)*	89.5	(± 13.7)*
	Don't know how far	1,160	(± 2,300)*	1.0	(± 2.1)*
IV.20 DWS Main C.17 and B.24	Accidental spill of farm pesticide in the last 5 years:				
	Farm pesticides spilled	10,900	(± 15,400)*	2.4	(± 3.3)*
	No spill	452,000	(± 144,000)*	97.6	(± 3.3)*
	Don't know whether spilled	0	N/A	0.0	N/A
IV.21 DWS LAQ #1	Crops farmed within 1/2 mile of well in the last 3 years:				
	Yes	2,940,000	(± 654,000)	79.7	(± 8.1)
	No	672,000	(± 326,000)	18.2	(± 7.3)
	Don't know	79,000	(± 109,000)*	2.1	(± 3.0)*
IV.22 DWS LAQ #3	Pasture land within 1/2 mile of well in the last 3 years:				
	Yes	2,510,000	(± 718,000)	68.0	(± 9.9)
	No	1,060,000	(± 364,000)	29.3	(± 9.3)
	Don't know	97,600	(± 153,000)*	2.6	(± 4.2)*

Exhibit D-6 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in "Cropped and Vulnerable" County Subregions

Item	Questionnaire Item	Estimates for Rural Domestic Wells in "Cropped and Vulnerable" County Subregions			
		Number	(95% C.I.)	Percent (95% C.I.)	
IV.23 DWS LAQ #4 (IV.22 sub-items)	Pesticides used on pasture land within 1/2 mile of well in the last 3 years:				
	Yes	867,000	(± 411,000)	34.5	(± 13.5)
	No	1,640,000	(± 579,000)	65.5	(± 13.5)
	Don't know	0	N/A	0.0	N/A
IV.24 DWS LAQ #5	Major non-agricultural pesticide application within 1/2 mile of well in the last 3 years:				
	Yes	556,000	(± 282,000)	15.1	(± 7.2)
	No	3,020,000	(± 738,000)	81.9	(± 7.9)
	Don't know	113,000	(± 131,000)*	3.1	(± 3.6)*
IV.25 DWS LAQ #7	Accidental spill of any pesticide within 1/2 mile of well in the last 3 years:				
	Yes	10,100	(± 14,500)*	0.3	(± 0.4)*
	No	3,490,000	(± 789,000)*	94.6	(± 7.0)*
	Don't know	190,000	(± 261,000)*	5.1	(± 7.0)*
IV.26 DWS LAQ #9	Accidental spill of any hazardous chemical within 1/2 mile of well in the last 3 years:				
	Yes	3,690	(± 7,300)*	0.1	(± 0.2)*
	No	3,530,000	(± 795,000)*	95.5	(± 7.1)*
	Don't know	161,000	(± 261,000)*	4.4	(± 7.1)*
IV.27 DWS LAQ #11j	Golf course within 1/2 mile of well:				
	Yes	168,000	(± 144,000)	4.6	(± 3.8)
	No	3,460,000	(± 756,000)	93.6	(± 4.5)
	Don't know	67,000	(± 102,000)*	1.8	(± 2.8)*

Exhibit D-6 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in "Cropped and Vulnerable" County Subregions

Item	Questionnaire Item	Estimates for Rural Domestic Wells in "Cropped and Vulnerable" County Subregions			
		Number	(95% C.I.)	Percent	(95% C.I.)
IV.28	River, canal, bay, spring, pond, etc. within 1/2 mile of well:				
DWS	Yes	3,530,000	(± 793,000)	95.7	(± 3.7)
LAQ	No	139,000	(± 134,000)	3.8	(± 3.7)
#12	Don't know	18,400	(± 26,300)*	0.5	(± 0.7)*
IV.29	Irrigation within 1/2 mile of well:				
DWS	Yes	743,000	(± 403,000)	20.1	(± 10.3)
LAQ	No	2,910,000	(± 761,000)	78.8	(± 11.1)
#13	Don't know	38,500	(± 55,700)*	1.0	(± 1.5)*

* For particular responses to questionnaire items where the percent is extreme (i.e., near 0.0% or 100.0% and the sample size is relatively small), the 95% confidence intervals should be treated with caution. For further details see Section B6.4 of Appendix B.

N/A For particular responses to questionnaire items where the percent is equal to 0.0% or 100.0%, traditional 95% confidence intervals based solely on sampling error are not applicable. For further details see Section B6.4 of Appendix B.

Exhibit D-7

Estimated Number and Percent of Rural Domestic Wells in Counties with High Pesticide Use and High Vulnerability

Item	Questionnaire Item	Estimates for Rural Domestic Wells in Counties with High Pesticide Use and High Vulnerability			
		Number	(95% C.I.)	Percent	(95% C.I.)
V.1 DWS TLI #6	Septic system on the property:				
	Septic tank	312,000	(± 105,000)	91.1	(± 9.8)
	Septic field	306,000	(± 99,600)	89.4	(± 8.7)
	Cesspool	35,900	(± 70,300)	10.5	(± 12.6)
V.2 DWS WOR #1	Topographic setting at well:				
	Hilltop	27,500	(± 32,500)*	8.0	(± 10.2)*
	Hillside	26,000	(± 39,800)*	7.6	(± 11.6)*
	Flat valley	190,000	(± 151,000)	55.6	(± 35.7)
	Depression	0	N/A	0.0	N/A
	Plateau	14,700	(± 29,100)*	4.3	(± 8.5)*
	Other	83,700	(± 110,000)*	24.5	(± 34.2)*
	Don't know	0	N/A	0.0	N/A
V.3 DWS WOR #4	Description of land area within 300 feet of well:				
	Roofed	4,930	(± 9,760)*	1.4	(± 2.9)*
	Paved	0	N/A	0.0	N/A
	Graveled	4,880	(± 9,720)*	1.4	(± 2.9)*
	Exposed or vegetated soil	318,000	(± 115,000)*	92.9	(± 8.4)*
	Other	14,600	(± 24,400)*	4.3	(± 7.4)*
V.4 DWS WOR #3	Well protection at surface:				
	Well house or shed	85,100	(± 85,200)*	24.9	(± 26.9)*
	Concrete pad	23,000	(± 37,500)*	6.7	(± 11.4)*
	Covered pit	47,500	(± 64,200)*	13.9	(± 17.5)*
	Other	197,000	(± 131,000)*	57.5	(± 30.9)*
V.5 DWS Main D.3	Age of well:				
	< 5 years	67,100	(± 44,600)	19.6	(± 8.1)
	5 to 10 years	56,200	(± 30,500)	16.4	(± 9.1)
	11 to 20 years	123,000	(± 61,600)	35.9	(± 18.3)
	> 20 years	39,500	(± 35,600)	11.6	(± 10.3)
	Don't know	56,600	(± 44,800)	16.5	(± 9.1)

Exhibit D-7 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in Counties with High Pesticide Use and High Vulnerability

Item	Questionnaire Item	Estimates for Rural Domestic Wells in Counties with High Pesticide Use and High Vulnerability			
		Number	(95% C.I.)	Percent	(95% C.I.)
V.6	Well redrilled:				
DWS	Yes	14,700	(± 11,500)	4.3	(± 4.2)
Main	No	302,000	(± 107,000)	88.2	(± 2.6)
D.4	Don't know	25,700	(± 21,200)	7.5	(± 4.3)
V.7	Well depth:				
DWS	< 20 feet	16,700	(± 25,800)*	4.9	(± 7.3)*
Main	20 to 50 feet	96,600	(± 74,800)	28.2	(± 17.6)
D.6	51 to 100 feet	74,500	(± 40,400)	21.8	(± 9.3)
	101 to 200 feet	74,300	(± 40,400)	21.7	(± 14.4)
	201 to 500 feet	17,000	(± 26,000)*	5.0	(± 8.0)*
	> 500 feet	0	N/A	0.0	N/A
	Don't know	62,900	(± 46,600)	18.4	(± 11.2)
V.8	Well casing information:				
DWS	Well cased	280,000	(± 113,000)	82.0	(± 15.6)
Main	Not cased	21,900	(± 24,200)*	6.4	(± 7.4)*
D.8	Don't know casing	39,800	(± 41,400)*	11.6	(± 11.7)*
DWS	Cased to total depth	189,000	(± 87,200)	67.3	(± 12.7)
Main	Cased < total depth	10,700	(± 13,700)*	3.8	(± 5.3)*
D.10	Don't know casing depth	81,100	(± 54,200)	28.9	(± 14.9)
V.9	Well closed at ground surface:				
DWS	Yes	266,000	(± 126,000)*	77.8	(± 22.8)*
WOR	No	33,800	(± 66,100)*	9.9	(± 19.9)*
#2	Don't know	42,200	(± 56,300)*	12.3	(± 15.4)*
V.10	Aquifer:				
DWS	Single	94,100	(± 79,900)	27.5	(± 17.7)
Main	Double	156,000	(± 51,000)	45.7	(± 19.1)
D.17	Don't know	91,500	(± 62,300)	26.8	(± 14.9)

Exhibit D-7 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in Counties with High Pesticide Use and High Vulnerability

Item	Questionnaire Item	Estimates for Rural Domestic Wells in Counties with High Pesticide Use and High Vulnerability			
		Number	(95% C.I.)	Percent	(95% C.I.)
V.11 DWS Main B.14	Non-operating wells within 500 feet of the well:				
	Yes	82,700	(± 41,400)	24.2	(± 8.4)
	No	241,000	(± 84,800)	70.4	(± 9.1)
	Don't know	18,700	(± 18,100)	5.5	(± 4.8)
V.12 DWS Main B.1	Non-farm pesticides used in the last 3 years:				
	Used inside house	300,000	(± 106,000)	87.8	(± 6.2)
	Not used inside house	41,700	(± 26,20)	12.2	(± 6.2)
	Don't know	0	N/A	0.0	N/A
V.13 DWS Main B.2	Non-farm pesticides used in last 3 years:				
	Used on lawn	117,000	(± 56,900)	34.3	(± 18.8)
	Not used on lawn	225,000	(± 121,000)	65.8	(± 18.8)
	Don't know	0	N/A	0.0	N/A
V.14 DWS Main B.3	Non-farm pesticides used in last 3 years:				
	Used in garden	152,000	(± 53,800)	44.5	(± 13.7)
	Not used in garden	190,000	(± 95,300)	55.5	(± 13.7)
	Don't know	0	N/A	0.0	N/A
V.15 DWS Main B.4	Non-farm pesticides stored for more than 1 month in the last 3 years:				
	Non-farm pesticides stored	227,000	(± 65,200)	66.4	(± 10.9)
	Not stored	115,000	(± 67,800)	33.6	(± 10.9)
	Don't know whether stored	0	N/A	0.0	N/A
DWS Main B.5	Stored < 100 feet from well	177,000	(± 60,500)	77.9	(± 8.0)
	Stored ≥ 100 feet from well	43,100	(± 22,000)	19.0	(± 11.1)
	Don't know where stored	7,190	(± 14,400)*	3.2	(± 6.3)*

Exhibit D-7 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in Counties with High Pesticide Use and High Vulnerability

Item	Questionnaire Item	Estimates for Rural Domestic Wells in Counties with High Pesticide Use and High Vulnerability			
		Number	(95% C.I.)	Percent (95% C.I.)	
V.16 DWS Main B.6	Non-farm pesticide container disposal in the last 3 years:				
	Containers disposed	35,900	(± 36,100)	10.5	(± 9.8)
	No disposal	306,000	(± 112,000)	89.5	(± 9.8)
	Don't know	0	N/A	0.0	N/A
DWS Main B.7	< 100 feet from well	17,400	(± 29,100)*	48.3	(±78.9)*
	≥ 100 feet from well	18,600	(± 24,800)*	51.7	(±78.9)*
	Don't know how far	0	N/A	0.0	N/A
V.17 DWS Main B.17 and B.18	Property farmed:				
	Yes	28,700	(± 20,600)	8.4	(± 6.2)
	No	313,000	(± 117,000)	91.6	(± 6.2)
DWS Main C.6	Pesticides used for farming in the last 5 years:				
	Pesticides used	26,100	(± 21,200)*	91.0	(±16.5)*
	Not used	2,590	(± 3,860)*	9.0	(±16.5)*
	Don't know whether used	0	N/A	0	N/A
V.18 DWS Main C.11 and B.20	Farm pesticides stored for more than 1 month in the last 5 years:				
	Farm pesticides stored	8,810	(± 12,800)	2.6	(± 3.7)
	Not stored	333,000	(± 117,000)	97.4	(± 3.7)
	Don't know whether stored	0	N/A	0.0	N/A

Exhibit D-7 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in Counties with High Pesticide Use and High Vulnerability

Item	Questionnaire Item	Estimates for Rural Domestic Wells in Counties with High Pesticide Use and High Vulnerability			
		Number	(95% C.I.)	Percent	(95% C.I.)
V.19 DWS Main C.14 and B.22	Farm pesticide container disposal in the last 5 years:				
	Containers disposed	8,210	(± 7,940)	28.7	(± 12.8)
	No disposal	20,500	(± 13,700)	71.4	(± 12.8)
	Don't know	0	N/A	0.0	N/A
DWS Main C.16 and B.23	< 100 feet from well	3,750	(± 7,460)*	45.6	(± 92.3)*
	≥ 100 feet from well	3,310	(± 5,150)*	40.3	(± 80.1)*
	Don't know how far	1,160	(± 2,300)*	14.1	(± 35.5)*
V.20 DWS Main C.17 and B.24	Accidental spill of farm pesticide in the last 5 years:				
	Farm pesticides spilled	0	N/A	0.0	N/A
	No spill	28,700	(± 20,600)	100.0	N/A
	Don't know whether spilled	0	N/A	0.0	N/A
V.21 DWS LAQ #1	Crops farmed within 1/2 mile of well in the last 3 years:				
	Yes	291,000	(± 134,000)	85.0	(± 13.7)
	No	51,300	(± 39,400)	15.0	(± 13.7)
	Don't know	0	N/A	0.0	N/A
V.22 DWS LAQ #3	Pasture land within 1/2 mile of well in the last 3 years:				
	Yes	176,000	(± 74,500)	51.5	(± 17.8)
	No	166,000	(± 89,600)	48.5	(± 17.8)
	Don't know	0	N/A	0.0	N/A

Exhibit D-7 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in Counties with High Pesticide Use and High Vulnerability

Item	Questionnaire Item	Estimates for Rural Domestic Wells in Counties with High Pesticide Use and High Vulnerability			
		Number	(95% C.I.)	Percent	(95% C.I.)
V.23 DWS LAQ #4 (V.23 sub-item)	Pesticides used on pasture land within 1/2 mile of well in the last 3 years: Yes No Don't know	 38,900 137,000 0	 (± 47,300)* (± 90,500)* N/A	 22.1 77.9 0.0	 (± 29.5)* (± 29.5)* N/A
V.24 DWS LAQ #5	Major non-agricultural pesticide application within 1/2 mile of well in the last 3 years: Yes No Don't know	 166,000 176,000 0	 (± 140,000) (± 154,000) N/A	 48.5 51.5 0.0	 (± 41.2) (± 41.2) N/A
V.25 DWS LAQ #7	Accidental spill of any pesticide within 1/2 mile of well in the last 3 years: Yes No Don't know	 0 342,000 0	 N/A (± 119,000) N/A	 0.0 100.0 0.0	 N/A N/A N/A
V.26 DWS LAQ #9	Accidental spill of any hazardous chemical within 1/2 mile of well in the last 3 years: Yes No Don't know	 0 342,000 0	 N/A (± 119,000) N/A	 0.0 100.0 0.0	 N/A N/A N/A
V.27 DWS LAQ #11j	Golf course within 1/2 mile of well: Yes No Don't know	 4,870 337,000 0	 (± 9,710)* (± 118,000)* N/A	 1.4 98.6 0.0	 (± 2.9)* (± 2.9)* N/A

Exhibit D-7 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in Counties with High Pesticide Use and High Vulnerability

Item	Questionnaire Item	Estimates for Rural Domestic Wells in Counties with High Pesticide Use and High Vulnerability			
		Number	(95% C.I.)	Percent (95% C.I.)	
V.28 DWS LAQ #12	River, canal, bay, spring, pond, etc. within 1/2 mile of well:				
	Yes	331,000	(± 111,000)*	96.7	(± 4.0)*
	No	11,200	(± 15,000)*	3.3	(± 4.0)*
	Don't know	0	N/A	0.0	N/A
V.29 DWS LAQ #13	Irrigation within 1/2 mile of well:				
	Yes	110,000	(± 99,600)	32.0	(± 23.2)
	No	233,000	(± 79,900)	68.0	(± 23.2)
	Don't know	0	N/A	0.0	N/A

* For particular responses to questionnaire items where the percent is extreme (i.e., near 0.0% or 100.0% and the sample size is relatively small), the 95% confidence intervals should be treated with caution, because the statistical assumptions are not justifiable in this case. For further details see Section B6.4 of Appendix B.

N/A For particular responses to questionnaire items where the percent is equal to 0.0% or 100.0%, traditional 95% confidence intervals based soley on sampling error are not applicable. For further details see Section B6.4 of Appendix B.

Exhibit D-7 (cont'd)

Estimated Number and Percent of Rural Domestic Wells in Counties with High Pesticide Use and High Vulnerability

Item	Questionnaire Item	Estimates for Rural Domestic Wells in Counties with High Pesticide Use and High Vulnerability			
		Number	(95% C.I.)	Percent	(95% C.I.)
V.28 DWS LAQ #12	River, canal, bay, spring, pond, etc. within 1/2 mile of well:				
	Yes	331,000	(± 111,000)*	96.7	(± 4.0)*
	No	11,200	(± 15,000)*	3.3	(± 4.0)*
	Don't know	0	N/A	0.0	N/A
V.29 DWS LAQ #13	Irrigation within 1/2 mile of well:				
	Yes	110,000	(± 99,600)	32.0	(± 23.2)
	No	233,000	(± 79,900)	68.0	(± 23.2)
	Don't know	0	N/A	0.0	N/A

* For particular responses to questionnaire items where the percent is extreme (i.e., near 0.0% or 100.0% and the sample size is relatively small), the 95% confidence intervals should be treated with caution, because the statistical assumptions are not justifiable in this case. For further details see Section B6.4 of Appendix B.

N/A For particular responses to questionnaire items where the percent is equal to 0.0% or 100.0%, traditional 95% confidence intervals based solely on sampling error are not applicable. For further details see Section B6.4 of Appendix B.

Form Approved: 3-31-88
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Expires: 4-30-90

U.S. Environmental Protection Agency
National Pesticide Survey

Team Leader Introduction
and
Well Observation Record
Community Water System

- Script for Scheduling Sampling Appointment
- Telephone and In-Person Contact (TIC) Record
- Continuation Sheets

August 5, 1988

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL PESTICIDE SURVEY

COMMUNITY WATER SYSTEM SURVEY

Script for Scheduling Sampling Appointment

PLACE RESPONDENT INFORMATION LABEL #1 HERE

Box 1

Hello, Mr./Ms. *(respondents name)*, my name is *(your name)*. I am with the *(your agency's name)*, and we are working with the U.S. Environmental Protection Agency on the National Pesticide Survey.

In the spring, you or another representative of your community water system spoke with one of our interviewers and gave us some general information about your water system. Since that time you should have received a letter in the mail explaining what the survey is about and also stating that your water system had been selected to be part of the national survey.

Did you receive that letter?

YES ☐ *(Go to Box 2)*

NO ☐ *(Verify the respondent's name and mailing address.)*

Name____________________________________

Street____________________________________

City____________________ State____ Zip________

We will send you another letter.

Box 2

Let me briefly review the contents of the letter for you. The purpose of the National Pesticide Survey is to obtain information on pesticide contamination in drinking water wells and to learn how the pesticides in these wells are associated with pesticide usage and groundwater vulnerability. Your water system has been randomly selected to be part of this survey and we would like to visit your system to take some water samples and to ask you some questions about well construction and the activities around the well.

I now need to ask you a few questions about your water system's operating status in order to determine if your water system is still eligible to participate in the survey.

Does your water system provide piped drinking water? (I.e., not just bottled water)

YES ☐ *(Continue)*

NO ☐ *(Thank respondent for their time and explain that they are not eligible.)*

Do you currently have one or more working wells that could be or are used as a drinking water source? (By working wells, we mean wells not permanently capped or shut down.)

YES ☐ *(Continue)*

NO ☐ *(Thank respondent for their time and explain that they are not eligible.)*

Does your water system currently have 15 or more customers that you could bill and/or meter individually? Count 1 household with 5 individuals as 1 customer.

YES ☐ *(Go to BOX 3)*

NO ☐ *(Continue)*

Does your water system provide piped water to 25 or more individuals? Count 1 household with 5 people as 5 individuals. Do not include wholesale water sales.

YES ☐ *(Go to BOX 3)*

NO ☐ *(Thank respondent for their time and explain that they are not eligible.)*

Box 3

I would like to arrange a convenient time for our team to visit you and your water system during the week of *(pre-determined sampling week)*. At that time, we would like to collect water samples and conduct an interview with the person most knowledgeable about well construction and pesticide use around the well.

When during that week would be the best time for us to visit you?

Box 4

(Write in the time of the appointment and the name or names of the people you will be contacting.)

Box 5 (Optional)

Could you please give me directions to a convenient place for us to meet that is also near the drinking water wells in your system?

Site Directions

(Write in directions to the meeting location.)

Box 6

It would be a great help if you could have any well construction records you have available when we visit. It may help refresh your memory and speed up the time involved.

Thank you very much for your cooperation with our research effort. I will be contacting you a day or two before our visit to confirm the time and place with you.

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL PESTICIDE SURVEY

TEAM LEADER INTRODUCTION
TELEPHONE & IN-PERSON CONTACT (TIC) RECORD

Contact Record					
Date	Start Time	End Time	Your Initials	Result Code	Person Contacted/Comments

Telephone Result Codes

1 = Ring no answer/busy
2 = Refusal
3 = Callback
4 = Not locatable
5 = Scheduled a visit
6 = Other (Specify in Comments, above)

In-Person Result Codes

7 = Respondent unavailable
8 = Substitute respondent
9 = Rescheduled appointment
10 = Refusal/Breakoff
11 = Unlocatable site
12 = Other (Specify in Comments, above)
PC = Partially complete case
C = Complete case

Visit rescheduled for: ___/___/___/___/ at _______ am/pm

Team Leader Name: ______________________________________

U.S. Environmental Protection Agency
National Pesticide Survey

Community Water System
Team Leader Introduction

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL PESTICIDE SURVEY

TEAM LEADER INTRODUCTION
COMMUNITY WATER SYSTEM

Box 1

Introduction

Hello, Mr./Ms. *(respondent's name)*, my name is *(your name)*. I'm with *(your office)*. We are working with the U.S. Environmental Protection Agency on the National Pesticide Survey. I spoke with you *(yesterday or date of conversation)* about including the *(CWS name)* in this research.

I would like to introduce the other member(s) of our survey team, *(name, office)* and *(name, office)*.

We will begin by asking you a few questions about the *(CWS name)* system but, first, I would like to make sure we have recorded your name correctly.

1. Will you please spell your first and last name? *(Circle Mr. or Ms. and print respondent's name below.)*

   Respondent name: *Mr./Ms.* ____
   (First name) *(Last name)*

2. What is your job title? *(Print respondent's job title below.)*

   Title: ____

Box 2

[illegible]

Team Leader Instructions

Follow the instructions next to the box marked with an "X".

☐ YOU MUST SELECT A WELL. (Continue with Box 3.)

☐ THE TEAM WILL SAMPLE WATER FROM THE FIRST AVAILABLE CHOICE LISTED BELOW. Mark an "X" in the box next to the first well choice, describe to the respondent the well from which you want to sample water, and go to Box 7, pg. 8. If, for some reason, the team cannot sample water from the first choice, explain the reason in the Comments section below and select the next choice.

Choice 1 ☐ Well # ___ Well Identifier ______________________________

____

Choice 2 ☐ Well # ___ Well Identifier ______________________________

____

Choice 3 ☐ Well # ___ Well Identifier ______________________________

____

(If you cannot sample from any of the above, call the ICF hotline 1-800-451-7896.)

Comments

Box 3

You will identify the number of wells used by the CWS.

Now, I would like to ask you a few questions about the wells that the *(name of CWS)* uses as a source of water

3. What is the total number of wells in the water system? *(Circle one number.)*

One well	01	*(Go to Box 4)*
Two or more wells *(Enter the number of wells:* |__|__|__|__| *)*	96	*(Skip to Box 5)*
None	97	*(Thank respondent for his/her time. Call 1-800-451-7896.)*
Don't know	98	*(Skip to Box 5)*

[illegible]

[illegible]

4. Is the well used for drinking water?

Yes 01
No .... 02 *(Thank respondent for his/her time. Call 1-800-451-7896.)*

Don't know .... 98 *(Thank respondent for his/her time. Call 1-800-451-7896.)*

The next question is about working wells. Working wells include wells that are currently pumping water or wells that are temporarily not in operation. Working wells do not include wells that are permanently capped or shut down.

5. Is this a working well?

Yes 01
No .... 02 *(Thank respondent for his/her time. Call 1-800-451-7896.)*
Don't know 98

6. Can we collect a sample before treatment from this well?

Yes 01
No .... 02 *(Thank respondent for his/her time. Call 1-800-451-7896.)*

Don't know 98

7. We would like to sample water from your well. *(Skip to Box 7, pg. 8)*

Box 5

[illegible] has more than one well. You will identify all eligible wells at the CWS.

8. Of the *(number of wells in Box 3)* wells, how many wells in the water system are used to supply drinking water?

|_|_|_|_| **Wells**

None .... 97 } *(Thank respondent for his/her time. Call 1-800-451-7896.)*

Don't know .... 98 }

The next question is about working wells. Working wells include wells that are currently pumping water or wells that are temporarily not in operation. Working wells do not include wells that are permanently capped or shut down.

9. Of the *(number of wells listed in Q.8)* drinking water wells, how many are currently working?

|_|_|_|_| **Working wells**

None .... 97 } *(Thank respondent for his/her time. Call 1-800-451-7896.)*

Don't know .... 98 }

10. Please list and describe all *(number of wells in Q.9)* working drinking water wells. When listing each well, describe each as you would normally identify them.

(a) *Does the respondent have a prepared listing of his/her own?*

Yes 01

No .... 02 *(Continue with "Well Listing Sheet" on next page.)*

(b) *If yes, go through the list with the respondent and cross out all wells that are not working drinking water wells. Number the working drinking water wells. Keep the listing and return it with the questionnaire. (Skip to Box 6).*

Well Listing Sheet

List each working drinking water well at the CWS. For each well, record the identifying information, such as location, special ID number, or any other information that uniquely identifies the well. If you are listing more than ten wells, use the continuation sheet at the end of the Team Leader Introduction.

Well Listing #	Identifying Information	Comments (e.g., reason why well cannot be sampled)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Box 6

From the list of working drinking water wells, you will select one well for sampling.

You will select the well for sampling based on the random numbers listed below in this box.

11. Can we collect a sample before treatment from ...

Choice	Well Number	Yes		No	Don't Know
1	______	01		02 *(Go to Choice 2)*	98 *(Go to Choice 2)*
2	______	01	*(Skip to Q12)*	02 *(Go to Choice 3)*	98 *(Go to Choice 3)*
3	______	01		02 *(Go to Choice 4)*	98 *(Go to Choice 4)*
4	______	01		02 *(Go to Choice 5)*	98 *(Go to Choice 5)*
5	______	01		02 *(Go to Choice 6)*	98 *(Go to Choice 6)*
6	______	01		02 *(See RULE)*	98 *(See RULE)*
Other	______			*(Explain each "No" or "DK" on Well Listing Sheet)*	

RULE: If the respondent answers "no" or "don't know" to all well numbers listed, go back to the Well Listing Sheet and identify the first well from which water can be sampled. Enter that well number on the line next to "Other". Then continue with Q.12. If no wells can be sampled, call the ICF hotline 1-800-451-7896.

12. We would like to sample well # *(well number)* which is *(respondent's well description)*. *(Continue with Box 7).*

[illegible]

Will you please show us where (*the well*) is located?

(The respondent will need to return to his/her office with the interviewer after they have located the well and answered the rest of the questions in the Team Leader Introduction. Take a few minutes to determine the logistics of transportation between the office and the well with the respondent.)

(After you have arrived at the well:)

I need to ask you a few questions about this well.

13. Which of the following treatments are applied to the water from the well? (*Circle a number for each item.*)

	Yes	No	DK
a. Water softener	01	02	98
b. Filter on the well	01	02	98
c. Fluoride treatment	01	02	98
d. Chlorine treatment	01	02	98
e. Activated carbon or charcoal treatment	01	02	98
f. What other treatment *(Specify)* ______________________	01	02	98

14. Which of the following are within 300 feet of the well? (*Circle a number for each item.*)

	Yes	No	DK
a. Septic tank	01	02	98
b. Septic field	01	02	98
c. Cesspool	01	02	98
d. What other sewage systems *(Specify)* ______________________	01	02	98

(Continue with Box 8).

Box 8

Do not [illegible] and Q. 16 to the respondent. You will examine the well and determine whether you can take water samples before treatment.

15. Can water be sampled from this well before treatment?

Yes	01	(Skip to Q.17)
No	02	(Explain the reason on the Comments sheet on pg. 6 and continue with Q.16.)

16. Did you select the well number from Box 2? (Circle one number)

Yes	01	(Go back to Box 2, pg.2, and select the next available choice.)
No (Respondent has only one well)	02	(Thank respondent for his/her time. Call 1-800-451-7896.)
No (Respondent has more than one well) ...	03	(Go back to Q.11 in Box 6 and select the next choice.)

17. We now need to sketch the well, its associated plumbing, the water delivery system, and any water treatment or holding tanks. *Ask the respondent to help you by pointing out the features of the well system, if necessary. On this sketch, please identify with an asterisk (*) exactly where you took samples*

N

↑

SCALE: 1 INCH = ________

18. *Ask the respondent to survey the area within 300 feet of the well with you, and help you locate all of the features in the check list at the bottom of the page. Mark [X] next to each feature for which you have checked, whether or not it is present within 300 feet of the well, on the checklist at the bottom of the page. Sketch and label each feature in the space provided.*

X

Well

N

↑

SCALE: 1 INCH = ________

I have looked for:

☐ Drainage ditches
☐ Bodies of water
☐ Septic tanks
☐ Septic fields
☐ Cesspools
☐ Farmland
☐ Cropland
☐ Pasture
☐ Wooded areas
☐ Buildings
☐ Other wells
☐ Paved areas

*** August 10, 1988 ***

Step 9

You will explain the sampling and interviewing activities.

It appears that we can sample water from this well. Before we begin taking water samples, we need to run the water for 15 to 30 minutes to make sure that we are drawing fresh well water and not just stagnant water from a holding tank. While we are doing this, would you like us to direct the water toward or away from anything in particular?

We can now sample the water from the well. If you wish, you may observe the sampling or proceed with the interview which requires us to go back to your office.

(Make sure that you provide the interviewer with the identifying information about the well.)

COMMENTS SHEET

C - ☐☐ - ☐☐ - ☐☐☐☐

Q9 Well Listing Sheet

(Continued)

Use this sheet if you have to list more than 10 wells. Assign a number to each working drinking water well that you have not yet listed and record the number(s) on this sheet. For each well, record the identifying information, such as location, special ID number, or any other information that uniquely identifies the well.

Well Listing #	Identifying Information	Comments (e.g., reason why well cannot be sampled)
___	___	___
	___	___
___	___	___
	___	___
___	___	___
	___	___
___	___	___
	___	___
___	___	___
	___	___
___	___	___
	___	___
___	___	___
	___	___
___	___	___
	___	___
___	___	___
	___	___
___	___	___

U.S. Environmental Protection Agency
National Pesticide Survey

Community Water System
Well Observation Record

WELL OBSERVATION RECORD

(To be completed at the well site)

1. Which of the following best describes the topographic setting at the well? *(Circle one number.)*

Hilltop	01
Hillside	02
Flat valley	03
Depression	04
Plateau	05
What other setting *(Specify)* ______________________	06
Don't know	98

2. Is the well open or closed at the land surface ("closed" means covered with a fixed apparatus or device)? *(Circle one number.)*

Open	01
Closed	02
Don't know	98

3. Which of the following protects the well at the surface? *(Circle one number for each item.)*

		Yes	No	DK
a.	Well house or shed	01	02	98
b.	Concrete pad	01	02	98
c.	Sanitary or grouted seal	01	02	98
d.	Covered pit	01	02	98
e.	What other *(Specify)* ______________________	01	02	98

4. Which of the following best describes the area within 300 feet of the well? *(Circle one number.)*

Roofed (including building)	01
Paved	02
Graveled	03
Exposed or vegetated soil	04
Covered with other material *(Specify)* ______________________	05

5. Which of the following best describes the predominant soil condition in the area within 300 feet of the well? *(Circle one number.)*

No exposed or vegetated soil	01
Sandy/silty	02
Clay	03
Loamy	04
Sandy/loamy	05
Clay/loam	06
Other soil condition *(Specify)* ______________________	07
Don't know	98

6. Which of the following are present in the area within 300 feet of the well? *(Circle one number for each item.)*

	Yes	No	DK
a. Drainage ditch	01	02	98
b. Unlined body of water	01	02	98

7. Was the sample obtained before or after treatment? *(Circle one number.)*

Before treatment	01
After treatment	02
Not applicable	03
Don't know	98

8. Is there a pressure or holding tank in the system line? *(Circle one number.)*

Yes	01	
No	02	} *(Skip to Box 10)*
Don't know	98	

9. What is the total capacity of the pressure or holding tank? *(Enter the capacity and circle the code for the unit of measurement.)*

|_|_|_|_|

Gallons	01
Millions of gallons	02
Other (Specify, ______________________)	97
Don't know	98

10. Was the sample collected before or after the pressure or holding tank(s)? *(Circle one number.)*

Before	01
After	02
Don't know	98

Box 10

Write the numbers 0-9 in the blanks provided below. Place one number in each blank:

___	___	___	___	___	___	___	___	___	___
0	1	2	3	4	5	6	7	8	9

COMMENTS SHEET

Form Approved: 3-31-88
OMB No. 2040-0107
Expires: 4-30-90

Well Identifier

U.S. Environmental Protection Agency
National Pesticide Survey

Community Water System Questionnaire

- Telephone and In-Person Contact (TIC) Record
- Continuation Sheets

October 26, 1988

NATIONAL PESTICIDE SURVEY

COMMUNITY WATER SYSTEM
TELEPHONE & IN-PERSON CONTACT (TIC) RECORD

PLACE RESPONDENT INFORMATION LABEL #2 HERE

Contact Record

Date	Start Time	End Time	Your Initials	Result Code	Person Contacted/Comments

Telephone Result Codes

1 = Ring no answer/busy
2 = Refusal
3 = Callback
4 = Not locatable
5 = Scheduled a visit
6 = Other (Specify in Comments, above)

In-Person Result Codes

7 = Respondent unavailable
8 = Substitute respondent
9 = Rescheduled appointment
10 = Refusal/Breakoff
11 = Unlocatable site
12 = Other (Specify in Comments, above)
PC = Partially complete case
C = Complete case

Visit rescheduled for: ___/___/___ at ______ am/pm

Interviewer Name: ______________________________

U.S. Environmental Protection Agency
National Pesticide Survey

Community Water System Questionnaire

SECTION A

Section A primarily contains questions about the construction of the well,. This section also contains some questions about the aquifer that supplies water to the well. The last two questions in this section are about other wells in the vicinity of the sampled well. This section should be answered by the person most knowledgeable about the construction of the well.

Box 1

Name of respondent for Section A: ____________________

Has the respondent been introduced to the study?

Yes .... 01 *(Skip to Box 2)*
No .... 02 *(Introduction)*

Introduction

Hello, Mr./Ms. *(respondent's name)*, my name is *(your name)*. I'm with *(your office)* working with the U.S. Environmental Protection Agency on the National Pesticide Survey. The purpose of the National Pesticide Survey is to obtain information on pesticide contamination in drinking water wells and to learn how the pesticides in these wells are associated with pesticide usage and groundwater vulnerability. The *(identify well)* has been selected for sampling in this survey. I'm going to ask you a few questions about the construction of the well, its water, and pesticide use on the property where the well is located.

Before we get started, I would like to make sure we have recorded your name correctly. Will you please spell your first and last name? *(Print the respondent's first and last name.)*

Mr./Ms. ____________________
(First name) *(Last name)*

Did the respondent use any records to answer the question?

Yes *No*

Box 2

Mr./Ms. *(respondent's name)*, all of my questions refer to *(identify well)*.

The first few questions are about the construction of the well. If you have any drilling records or inspection documents, they would be helpful.

A1. In what year was the well originally constructed or drilled? *(Enter the year.)*

|_1_|___|___|___| Year
Don't know 98

1 2

A2. Since 19___, has the well been redrilled? *(Circle one number.)*

Yes 01
No .... 02 } *(Skip to Q.A4)*
Don't know 98

1 2

A3. In what year was the well most recently redrilled? *(Enter the year.)*

|_1_|___|___|___| Year
Don't know 98

1 2

A4. What is the elevation of the ground surface at the well, relative to Mean Sea Level? *(Enter the elevation and circle the code for the unit of measurement.)*

|___|___|___|___| Feet 01
Yards 02
Other (Specify, ______________________).. 97
Don't know 98

1 2

*** October 26, 1988 ***

Did the respondent use any records to answer the question?

Yes *No*

A5. What is the total depth of the well, that is, the total distance from the ground surface to the bottom of the well? *(Enter the depth and circle the code for the unit of measurement.)*

			Yes	No
___ ___ ___ ___	Feet	01	1	2
	Yards	02		
	Other (Specify. ____________________)	97		
	Don't know	98		

A6. Is the well drilled into bedrock? *(Circle one number.)*

		Yes	No
Yes	01	1	2
No	02		
Don't know	98		

Box 3

I would like to ask a few questions about the well casing. As shown in Diagram 1, a casing is a material that lines the well and prevents it from caving in.

A7. Does the well have a casing? *(Circle one number.)*

			Yes	No
Yes	01	*(Skip to Q.A9)*	1	2
No	02			
Don't know	98			

A8. What is the borehole diameter of the well? *(Enter the diameter and circle the code for the unit of measurement.)*

				Yes	No
|__|__|__|	Inches	01	} *(Skip to Box 6, pg.7)*	1	2
	Feet	02			
	Other (Specify, ____________)	97	} *(Skip to Box 6, pg.7)*		
	Don't know	98			

Did the respondent use any records to answer the question?

		Yes	No

A9. What is the inside diameter of the well? *(Enter the diameter and circle the code for the unit of measurement.)*

|__|__|__|

		Yes	No
Inches	01	1	2
Feet	02		
Other (Specify, __________)	97		
Don't know	98		

A10. Which of the following materials was used to case the well. . .? *(Read each item to the respondent and circle one number for each item.)*

		Yes	No	DK	Records: Yes	Records: No
a.	Plastic pipe (PVC)	01	02	98	1	2
b.	Concrete or cement	01	02	98	1	2
c.	Metal (steel, iron, galvanized metal)	01	02	98	1	2
d.	Tile, brick, or stone	01	02	98	1	2
e.	What other material *(Specify)* __________	01	02	98	1	2

A11. Is the well cased to its total depth? *(Circle one number.)*

			Yes	No
Yes	01	*(Skip to Box 4)*	1	2
No	02			
Don't know	98			

A12. What is the distance from the ground surface to the bottom of the casing? *(Enter the distance and circle the code for the unit of measurement.)*

|__|__|__|__|

		Yes	No
Feet	01	1	2
Yards	02		
Other (Specify, __________)	97		
Don't know	98		

Did the respondent use any records to answer the question?

Yes *No*

Box 4

As shown in Diagram 2, some wells have openings or perforations in the side of the casing to allow water to come into the well. These openings are called screens. Diagram 3 shows a well with multiple screens. I would now like to ask you a few questions about screens in your well's casing.

A13. Does the well have any screens in the casing? *(Circle one number.)*

Yes 01
No .... 02 } *(Skip to Box 5)*
Don't know .... 98 } *(Skip to Box 5)*

1 2

A14. How many screens are in the casing? *(Circle one number.)*

One 01
Two or more .... 02 *(Skip to Q.A16)*
Don't know .... 98 *(Skip to Box 5)*

1 2

A15. What is the length of the screen? *(Enter the length and circle the code for the unit of measurement.)*

|__|__|__|__| Feet .... 01 } *(Skip to Box 5)*
Yards .... 02 } *(Skip to Box 5)*
Other (Specify, ____________) .. 97 } *(Skip to Box 5)*
Don't know .... 98 } *(Skip to Box 5)*

1 2

A16. **What is the total distance from the ground surface to the top of the highest screen?** *(Enter the distance and circle the code for the unit of measurement.)*

|__|__|__|__| Feet 01
Yards 02
Other (Specify, ____________) .. 97
Don't know 98

1 2

Did the respondent use any records to answer the question?

No
Yes

A17. What is the total distance from the ground surface to the bottom of the deepest screen? *(Enter the distance and circle the code for the unit of measurement.)*

|_|_|_|_| Feet 01 1 2
Yards 02
Other (Specify, ________________________) .. 97
Don't know 98

Box 5

The next few questions are about well grouting. Grout is a material placed between the casing and the sides of the borehole to prevent water from moving downward into the well.

A18. Is the well grouted? *(Circle one number.)*

Yes 01 1 2
No .... 02 } *(Skip to Box 6)*
Don't know 98

A19. What is the distance from the ground surface to the bottom of the grouting? *(Enter the distance and circle the code for the unit of measurement.)*

|_|_|_|_| Feet 01 1 2
Yards 02
Other (Specify, ________________________) .. 97
Don't know 98

Did the respondent use any records to answer the question?

A20. Which of the following materials was used to fill the space between the casing and the side of the borehole . . .? *(Read each item to the respondent and circle one number for each item.)*

		Yes	No	DK	Yes	No
a.	Backfill	01	02	98	1	2
b.	Bentonite	01	02	98	1	2
c.	Cement	01	02	98	1	2
d.	What other material *(Specify)* ________________	01	02	98	1	2

> *Box 6*
>
> The next two questions are about the well cap. By a cap, I mean an apparatus or device fixed over the well to cover it.

A21. Is the well capped at the ground surface? *(Circle one number.)*

Yes	01		1	2
No	02	} *(Skip to Box 7)*		
Don't know	98			

A22. Which of the following materials was used to cap the well . . .? *(Read each item to the respondent and circle one number for each item.)*

		Yes	No	DK		
a.	Cement	01	02	98	1	2
b.	Plastic	01	02	98	1	2
c.	What other material *(Specify)* ________________	01	02	98	1	2

Did the respondent use any records to answer the question?

Yes *No*

Box 7

The next question is about the typical distance from the ground surface to the water surface in the well. When answering the following question, please do not include depths measured during floods, droughts, or other highly unusual conditions.

A23 During the past 12 months, what was the typical distance from the ground surface to the water surface in the well? *(Enter the distance and circle the code for the unit of measurement.)*

|_|_|_|_|

Feet 01   1   2
Yards 02
Other (Specify, ______________________) .. 97
Don't know 98

A24 What is the distance from the ground surface to the well pump? *(Enter the distance and circle the code for the unit of measurement.)*

|_|_|_|_|

Feet 01   1   2
Yards 02
Other (Specify, ______________________) .. 97
Don't know 98

Did the respondent use any records to answer the question?

Yes ↓ *No* ↓

Box 8

The next question asks about the type of aquifer that supplies your well water.

An aquifer is an underground layer of porous rock or sand that contains water. Two common types of aquifers are confined aquifers and surficial or water table aquifers.

If your well is cased and it is drilled into a confined aquifer, the water level in the well will be higher than the water level of the surrounding aquifer.

If your well is drilled into a surficial or water table aquifer, the water level will not be higher than the water level of the surrounding aquifer.

A25. Does the well draw water from a ...? *(Read each item to the respondent and circle one number for each item.)*

		Yes	No	*DK*	*Yes*	*No*
a.	Confined aquifer	01	02	98	1	2
b.	Surficial or water table aquifer	01	02	98	1	2
c.	What other type of aquifer *(Specify)* ______________	01	02	98	1	2

Box 9

The next few questions are about the well's operating status and how long it has been working since the last interruption in operation. By interruption, I mean a temporary shutting down of the well because equipment repairs are needed or water demand by the users is low, or for other reasons.

A26. Is the well currently operating? *(Circle one number.)*

			Yes	*No*
Yes	01		1	2
No	02	} *(Skip to Q.A29)*		
Don't know	98			

Did the respondent use any records to answer the question?

Yes No

A27. Has there been an interruption in the operation of this well since it was drilled? *(Circle one number.)* 1 2

Yes	01	
No	02	} *(Skip to Q.A29)*
Don't know	98	

A28. How long has this well been working since the last interruption in operation? *(Enter the number and circle the code for the unit of time.)* 1 2

|__|__|__|

Years	01
Months	02
Weeks	03
Days	04
Don't know	98

A29. What is the well pump's rated capacity? *(Enter the capacity and circle the code for the unit of measurement.)* 1 2

|__|__|__|__|__|__|

Gallons per minute	01
Gallons per hour	02
Other (Specify, ________________)	97
Don't know	98

A30. What was the average pumping rate of the well during the last 12 months? *(Enter the pumping rate and circle the code for the unit of measurement.)* 1 2

|__|__|__|__|__|__|

Gallons per minute	01
Gallons per hour	02
Other (Specify, ________________)	97
Don't know	98

Did the respondent use any records to answer the question?

Yes No

A31 What was the total amount of groundwater withdrawn from the well during the last 12 months? *(Enter the amount and circle the code for the unit of measurement.)*

|_|_|_|_|_|_|	Millions of gallons	01	1	2
	Gallons	02		
	Other (Specify, ________)	97		
	Don't know	98		

> *Box 10*
>
> My next question is about the drawdown for the well. The drawdown is the amount by which the water level is lowered, in the well, due to pumping.

A32. What is the well's drawdown? *(Enter the distance of the drawdown and circle the code for the unit of measurement.)*

|_|_|_|_|	Feet	01	1	2
	Yards	02		
	Other (Specify, ________)	97		
	Don't know	98		

A33. Is there a reservoir into which groundwater is pumped? *(Circle one number.)*

Yes	01		1	2
No	02	} *(Skip to Box 11)*		
Don't know	98			

A34. What is the size or capacity of the reservoir? *(Enter the size/capacity and circle the code for the unit of measurement.)*

|_|_|_|_|	Gallons	01	1	2
	Millions of gallons	02		
	Other (Specify, ________)	97		
	Don't know	98		

Box 11

The next few questions are about other wells within 500 feet of the well

A35. Are there any other operating wells within 500 feet of the well? *(Circle one number.)*

Yes	01	
No	02	*(Skip to Q. A37)*
Don't know	98	

A36. I will now read to you a list of well types, such as "private drinking well," "community drinking well" and so on. When I read each well type, please tell me how many operating wells of that type are located within 500 feet of the well. *(Read each item to the respondent and write the number of wells for that use in the space provided. Enter "00" if necessary.)*

		Number of wells
a.	Private drinking	__ __
b.	Community drinking	__ __
c.	Irrigation	__ __
d.	What other well types *(Specify)* ______________________________	__ __

A37. Are there any abandoned or non-operating wells within 500 feet of the well? *(Circle one number.)*

Yes	01	
No	02	*(Skip to Box 12)*
Don't know	98	

A38. How many abandoned or non-operating wells are within 500 feet of the well? *(Enter the number.)*

|__|__|__| Wells

Don't know 98

A39. *Read questions a-c for every well that is not operating . . .*

WELL #1	WELL #2	WELL #3
a. Is the first well open or capped? Open .... 01 Capped .... 02 *Don't know* 98	a. Is the second well open or capped? Open .... 01 Capped .... 02 *Don't know* 98	a. Is the third well open or capped? Open .... 01 Capped .... 02 *Don't know* 98
b. Is the hole all filled, partially filled, or not filled? All filled .... 01 Partially filled .... 02 Not filled .... 03 *(Skip to Well #2)* *Don't know* .... 98 *(Skip to Well #2)*	b. Is the hole all filled, partially filled, or not filled? All filled .... 01 Partially filled .... 02 Not filled .... 03 *(Skip to Well #3)* *Don't know* .... 98 *(Skip to Well #3)*	b. Is the hole all filled, partially filled, or not filled? All filled .... 01 Partially filled .... 02 Not filled .... 03 *(Use A39 Continuation Sheet or skip to Box 12)* *Don't know* .... 98 *(Use A39 Continuation Sheet or skip to Box 12)*
c. What material was used to fill the well hole? *(Specify)* ______________________ 01 *(Go to well #2)* *Don't know* .... 98 *(Go to well #2)*	c. What material was used to fill the well hole? *(Specify)* ______________________ 01 *(Go to well #3)* *Don't know* .... 98 *(Go to well #3)*	c. What material was used to fill the well hole? *(Specify)* ________________ 01 *(Use A39 Continuation Sheet or skip to Box 12)* *Don't know* ...... 98 *(Use A39 Continuation Sheet or skip to Box 12)*

Box 12

Will the same respondent answer the questions in Section B?

Yes .... *01* *(Skip to Box 14)*
No *02*

Box 13

I have no further questions. I appreciate your taking the time to participate in this research. In case I need to contact you again, will you please give me your telephone number starting with your area code?

Respondent's telephone number: |_|_|_| |_|_|_| - |_|_|_|_|

Thank you again for your help.

SECTION B

***Section B contains questions about the usage of non-farm pesticides on the property where the well is located.** This section should be answered by the person who is most knowledgeable about the application of non-farm pesticides on the property.*

Box 14

Name of respondent for Section B: ________________________________

Has the respondent been introduced to the study?

Yes .... 01 *(Skip to Box 15)*
No .... 02 *(Introduction)*

Introduction

Hello, Mr./Ms. *(respondent's name)*, my name is *(your name)*. I'm with *(your office)* working with the U.S. Environmental Protection Agency on the National Pesticide Survey. The purpose of the National Pesticide Survey is to obtain information on pesticide contamination in drinking water wells and to learn how the pesticides in these wells are associated with pesticide usage and groundwater vulnerability. The *(identify well)* has been selected for sampling in this survey. I'm going to ask you a few questions about the construction of the well, its water, and pesticide use on the property where the well is located.

Before we get started, I would like to make sure we have recorded your name correctly. Will you please spell your first and last name? *(Print the respondent's first and last name.)*

Mr./Ms. ________________________________
(First name) *(Last name)*

Box 15

All of my questions refer to *(Identify well)*.

The next few questions are about pesticides used to control weeds, insects, or other pests on the property where the well is located. For this survey, pesticides include all chemicals used to control insects, plants, fungi, nematodes, and rodents.

When answering these questions, please do not include pesticides used for farming on the property where the well is located.

B1. Between January 1, 1987 and the present, have any pesticides been used for controlling weeds, insects, or other pests on the property where the well is located, other than for farming? *(Circle one number.)*

Yes	01	
No	02	} *(Skip to Box 16, pg 20)*
Don't know	98	

B2(a). In 1989, were any non-farm pesticides used on the property where the well is located?

Yes 01
No .... 02 *(Skip to B2(b))*

(If yes), first name the pest, next the pesticide, then the rate of application. When naming the pest, include any insects, weeds, rodents, or other pests against which you use pesticides. *(If the respondent lists more than four pests for 1989, continue listing the pests on the B2 continuation sheet. Also, if more than four pesticides are applied to a pest, continue listing the pesticides on the B2 continuation sheet.)*

Pest	1989 Pesticide	Rate (pounds per acre per year)	DK	Active ingredient or Diluted?
1. ____________	1. ____________	___ ___ ___ ___	98	A D
	2. ____________	___ ___ ___ ___	98	A D
	3. ____________	___ ___ ___ ___	98	A D
	4. ____________	___ ___ ___ ___	98	A D
Don't know 98	*Don't know* 98			
2. ____________	1. ____________	___ ___ ___ ___	98	A D
	2. ____________	___ ___ ___ ___	98	A D
	3. ____________	___ ___ ___ ___	98	A D
	4. ____________	___ ___ ___ ___	98	A D
Don't know 98	*Don't know* 98			
3. ____________	1. ____________	___ ___ ___ ___	98	A D
	2. ____________	___ ___ ___ ___	98	A D
	3. ____________	___ ___ ___ ___	98	A D
	4. ____________	___ ___ ___ ___	98	A D
Don't know 98	*Don't know* 98			
4. ____________	1. ____________	___ ___ ___ ___	98	A D
	2. ____________	___ ___ ___ ___	98	A D
	3. ____________	___ ___ ___ ___	98	A D
	4. ____________	___ ___ ___ ___	98	A D
Don't know 98	*Don't know* 98			

B2(b). In 1988, were any non-farm pesticides used on the property where the well is located?

Yes 01
No .... 02 *(Skip to B2(c))*

(If yes), first name the pest, next the pesticide, then the rate of application. *(If the respondent lists more than four pests for 1988, continue listing the pests on the B2 continuation sheet. Also, if more than four pesticides are applied to a pest, continue listing the pesticides on the B2 continuation sheet.)*

Pest	1988 Pesticide	Rate (pounds per acre per year)	DK	Active Ingredient or Diluted?
1. ____________	1. ________________	|_|_|_|_|	98	A D
	2. ________________	|_|_|_|_|	98	A D
	3. ________________	|_|_|_|_|	98	A D
	4. ________________	|_|_|_|_|	98	A D
Don't know 98	*Don't know* 98			
2. ____________	1. ________________	|_|_|_|_|	98	A D
	2. ________________	|_|_|_|_|	98	A D
	3. ________________	|_|_|_|_|	98	A D
	4. ________________	|_|_|_|_|	98	A D
Don't know 98	*Don't know* 98			
3. ____________	1. ________________	|_|_|_|_|	98	A D
	2. ________________	|_|_|_|_|	98	A D
	3. ________________	|_|_|_|_|	98	A D
	4. ________________	|_|_|_|_|	98	A D
Don't know 98	*Don't know* 98			
4. ____________	1. ________________	|_|_|_|_|	98	A D
	2. ________________	|_|_|_|_|	98	A D
	3. ________________	|_|_|_|_|	98	A D
	4. ________________	|_|_|_|_|	98	A D
Don't know 98	*Don't know* 98			

B2(c). In 1987, were any non-farm pesticides used on the property where the well is located?

Yes 01
No .... 02 *(Skip to Q B3)*

(If yes), first name the pest, next the pesticide, then the rate of application. *(If the respondent lists more than four pests for 1987, continue listing the pests on the B2 continuation sheet. Also, if more than four pesticides are applied to a pest, continue listing the pesticides on the B2 continuation sheet.)*

Pest	1987 Pesticide	Rate (pounds per acre per year)	DK	Active Ingredient or Diluted?	
1. ________	1. ________	|_|_|_|_|	98	A	D
	2. ________	|_|_|_|_|	98	A	D
	3. ________	|_|_|_|_|	98	A	D
	4. ________	|_|_|_|_|	98	A	D
Don't know 98	*Don't know* 98				
2. ________	1. ________	|_|_|_|_|	98	A	D
	2. ________	|_|_|_|_|	98	A	D
	3. ________	|_|_|_|_|	98	A	D
	4. ________	|_|_|_|_|	98	A	D
Don't know 98	*Don't know* 98				
3. ________	1. ________	|_|_|_|_|	98	A	D
	2. ________	|_|_|_|_|	98	A	D
	3. ________	|_|_|_|_|	98	A	D
	4. ________	|_|_|_|_|	98	A	D
Don't know 98	*Don't know* 98				
4. ________	1. ________	|_|_|_|_|	98	A	D
	2. ________	|_|_|_|_|	98	A	D
	3. ________	|_|_|_|_|	98	A	D
	4. ________	|_|_|_|_|	98	A	D
Don't know 98	*Don't know* 98				

B3. Approximately how many feet from the well was the closest non-farm pesticide application area? *(Enter the distance and circle the code for the unit of measurement.)*

|__|__|__|__|

Feet	01
Yards	02
Other (Specify, ________________)	97
Don't know	98

Box 16

The next few questions are about storage and disposal of pesticides on the property where the well is located. When answering these questions please do not include pesticides used for farming around the well.

B4. **Between** January 1, 1987 and the present, have any non-farm pesticides been stored, for more than one month, on the property where the well is located? *(Circle one number.)*

Yes	01	
No	02	} *(Skip to Q B6)*
Don't know	98	

a. Starting with 1989, what pesticides were stored for more than one month? *(List each pesticide. If more than four pesticides were stored, continue listing the pesticides on the "Generic" continuation sheet.)*

Pesticide
1. ______
2. ______
3. ______
4. ______

Don't know	98
None	99

b. Thinking back to 1988, what pesticides were stored for more than one month? *(List each pesticide. If more than four pesticides were stored, continue listing the pesticides on the "Generic" continuation sheet.)*

Pesticide
1. ______
2. ______
3. ______
4. ______

Don't know	98
None	99

c. Thinking back to 1987, what pesticides were stored for more than one month? *(List each pesticide. If more than four pesticides were stored, continue listing the pesticides on the "Generic" continuation sheet.)*

Pesticide
1. ______
2. ______
3. ______
4. ______

Don't know	98
None	99

B5. Approximately how many feet from the well was the closest non-farm pesticide storage site? *(Enter the distance and circle the code for the unit of measurement.)*

|_|_|_|_|

Feet	01
Yards	02
Other (Specify, ______)	97
Don't know	98

B6. **Between** January 1, 1987 and the present, have any non-farm pesticides or pesticide containers been discarded or disposed on the property where the well is located? *(Circle one number.)*

Yes	01	
No	02	} *(Skip to C B8)*
Don't know	98	

a. Starting with 1989, what pesticides were disposed? *(List each pesticide. If more than four pesticides were disposed, continue listing the pesticides on the "Generic" continuation sheet.)*

Pesticide
1. ____________________
2. ____________________
3. ____________________
4. ____________________

Don't know	98
None	99

b. Thinking back to 1988, what pesticides were disposed? *(List each pesticide. If more than four pesticides were disposed, continue listing the pesticides on the "Generic" continuation sheet.)*

Pesticide
1. ____________________
2. ____________________
3. ____________________
4. ____________________

Don't know	98
None	99

c. Thinking back to 1987, what pesticides were disposed? *(List each pesticide. If more than four pesticides were disposed, continue listing the pesticides on the "Generic" continuation sheet.)*

Pesticide
1. ____________________
2. ____________________
3. ____________________
4. ____________________

Don't know	98
None	99

B7. Approximately how many feet was the closest non-farm pesticide disposal site from the well? *(Enter the distance and circle the code for the unit of measurement.)*

|_|_|_|_|

Feet	01
Yards	02
Other (Specify, ____________)	97
Don't know	98

B8. **Between January 1, 1987 and the present, has there been an accidental spill of any non-farm pesticide on the property where the well is located?** *(Circle one number.)*

Yes 01
No .... 02 } *(Skip to Box 17)*
Don't know .... 98 }

---

a. Starting with 1989, what pesticides were spilled? *(List each pesticide. If more than four pesticides were spilled, continue listing the pesticides on the "Generic" continuation sheet.)*

Pesticide
1. ____________________
2. ____________________
3. ____________________
4. ____________________

Don't know 98
None 99

b. Thinking back to 1988, what pesticides were spilled? *(List each pesticide. If more than four pesticides were spilled, continue listing the pesticides on the "Generic" continuation sheet.)*

Pesticide
1. ____________________
2. ____________________
3. ____________________
4. ____________________

Don't know 98
None 99

c. Thinking back to 1987, what pesticides were spilled? *(List each pesticide. If more than four pesticides were spilled, continue listing the pesticides on the "Generic" continuation sheet.)*

Pesticide
1. ____________________
2. ____________________
3. ____________________
4. ____________________

Don't know 98
None 99

B9. Approximately how many feet from the well was the closest non-farm pesticide spill? *(Enter the distance and circle the code for the unit of measurement.)*

|_|_|_|_|

Feet 01
Yards 02
Other (Specify, ____________________) 97
Don't know 98

Box 17

Will the same respondent answer the questions in Section C?

Yes .... 01 *(Skip to Box 19)*
No 02

Box 18

I have no further questions. I appreciate your taking the time to participate in this research. In case I need to contact you again, will you please give me your telephone number starting with your area code?

Respondent's telephone number: |_|_|_| |_|_|_| - |_|_|_|_|

Thank you again for your help.

SECTION C

Section C contains questions about farming on the property where the well is located. The questions in Section C should be answered by someone who is knowledgeable about the types of farm pesticides applied to the property.

Box 19

Name of respondent: ______________________________

Has the respondent been introduced to the study?

Yes .... 01 *(Skip to Box 20)*
No .... 02 *(Introduction)*

Introduction

Hello, Mr./Ms. *(respondent's name)*, my name is *(your name)*. I'm with *(your office)* working with the U.S. Environmental Protection Agency on the National Pesticide Survey. The purpose of the National Pesticide Survey is to obtain information on pesticide contamination in drinking water wells and to learn how the pesticides in these wells are associated with pesticide usage and groundwater vulnerability. The *(identify well)* has been selected for sampling in this survey. I'm going to ask you a few questions about the construction of the well, its water, and pesticide use on the property where the well is located.

Before we get started, I would like to make sure we have recorded your name correctly. Will you please spell your first and last name? *(Print the respondent's first and last name.)*

Mr./Ms. ______________________________
(First name) *(Last name)*

Box 20

All of my questions refer to *(identify well)*.

The next few questions are about pesticide use for farming on the property where the well is located. For this survey, pesticides include all chemicals used to control insects, plants, fungi, nematodes, and rodents.

C1. Between January 1, 1985 and the present, has anyone farmed the property on which the well is located? *(Circle one number.)*

Yes 01
No .... 02 } *(Skip to Box 21, pg 32)*
Don't know .... 98 } *(Skip to Box 21, pg 32)*

C2. Between January 1, 1985 and the present, have any pesticides been used for farming on the property where the well is located? *(Circle one number.)*

Yes 01
No .... 02 } *(Skip to Box 21, pg 32)*
Don't know .... 98 } *(Skip to Box 21, pg 32)*

C3(a). In 1989, were any pesticides used on the crops on the property where the well is located?

Yes 01
No .... 02 *(Skip to C3(b))*

(If yes), first name the crop, next the pesticide(s) applied to the crop, then the rate of application. *(If pesticides were applied to more than four crops in 1989, continue listing the crops on the C3 continuation sheet. Also, if more than four pesticides were applied to a crop, continue listing the pesticides that were applied to the crop on the C3 continuation sheet.)*

Crop	1989 Pesticide	Rate (pounds per acre per year)	DK	Active ingredient or Diluted?
1. ________	1. ____________	___ ___ ___ ___	98	A D
	2. ____________	___ ___ ___ ___	98	A D
	3. ____________	___ ___ ___ ___	98	A D
	4. ____________	___ ___ ___ ___	98	A D
Don't know 98	*Don't know* 98			
2. ________	1. ____________	___ ___ ___ ___	98	A D
	2. ____________	___ ___ ___ ___	98	A D
	3. ____________	___ ___ ___ ___	98	A D
	4. ____________	___ ___ ___ ___	98	A D
Don't know 98	*Don't know* 98			
3. ________	1. ____________	___ ___ ___ ___	98	A D
	2. ____________	___ ___ ___ ___	98	A D
	3. ____________	___ ___ ___ ___	98	A D
	4. ____________	___ ___ ___ ___	98	A D
Don't know 98	*Don't know* 98			
4. ________	1. ____________	___ ___ ___ ___	98	A D
	2. ____________	___ ___ ___ ___	98	A D
	3. ____________	___ ___ ___ ___	98	A D
	4. ____________	___ ___ ___ ___	98	A D
Don't know 98	*Don't know* 98			

C3(b). In 1988, were any pesticides used on the crops on the property where the well is located?

Yes 01
No .... 02 *(Skip to C3(c))*

(If yes), first name the crop, next the pesticides, then the rate of application *(If pesticides were applied to more than four crops in 1988, continue listing the crops on the C3 continuation sheet. Also, if more than four pesticides were applied to a crop, continue listing the pesticides that were applied to the crop on the C3 continuation sheet.)*

<table>
<tr><th>Crop</th><th>1988
Pesticide</th><th><u>Rate</u>
<i>(pounds per acre per year)</i></th><th><u>DK</u></th><th>Active Ingredient
or
Diluted?</th></tr>
<tr><td>1. ____________</td><td>1. ____________</td><td>|_|_|_|_|</td><td>98</td><td>A D</td></tr>
<tr><td></td><td>2. ____________</td><td>|_|_|_|_|</td><td>98</td><td>A D</td></tr>
<tr><td></td><td>3. ____________</td><td>|_|_|_|_|</td><td>98</td><td>A D</td></tr>
<tr><td></td><td>4. ____________</td><td>|_|_|_|_|</td><td>98</td><td>A D</td></tr>
<tr><td><i>Don't know</i> ...... 98</td><td><i>Don't know</i> .... 98</td><td></td><td></td><td></td></tr>
<tr><td>2. ____________</td><td>1. ____________</td><td>|_|_|_|_|</td><td>98</td><td>A D</td></tr>
<tr><td></td><td>2. ____________</td><td>|_|_|_|_|</td><td>98</td><td>A D</td></tr>
<tr><td></td><td>3. ____________</td><td>|_|_|_|_|</td><td>98</td><td>A D</td></tr>
<tr><td></td><td>4. ____________</td><td>|_|_|_|_|</td><td>98</td><td>A D</td></tr>
<tr><td><i>Don't know</i> .... 98</td><td><i>Don't know</i> .... 98</td><td></td><td></td><td></td></tr>
<tr><td>3. ____________</td><td>1. ____________</td><td>|_|_|_|_|</td><td>98</td><td>A D</td></tr>
<tr><td></td><td>2. ____________</td><td>|_|_|_|_|</td><td>98</td><td>A D</td></tr>
<tr><td></td><td>3. ____________</td><td>|_|_|_|_|</td><td>98</td><td>A D</td></tr>
<tr><td></td><td>4. ____________</td><td>|_|_|_|_|</td><td>98</td><td>A D</td></tr>
<tr><td><i>Don't know</i> .... 98</td><td><i>Don't know</i> .... 98</td><td></td><td></td><td></td></tr>
<tr><td>4. ____________</td><td>1. ____________</td><td>|_|_|_|_|</td><td>98</td><td>A D</td></tr>
<tr><td></td><td>2. ____________</td><td>|_|_|_|_|</td><td>98</td><td>A D</td></tr>
<tr><td></td><td>3. ____________</td><td>|_|_|_|_|</td><td>98</td><td>A D</td></tr>
<tr><td></td><td>4. ____________</td><td>|_|_|_|_|</td><td>98</td><td>A D</td></tr>
<tr><td><i>Don't know</i> .... 98</td><td><i>Don't know</i> .... 98</td><td></td><td></td><td></td></tr>
</table>

C3(c). In 1987, were any pesticides used on the crops on the property where the well is located?

Yes 01
No .... 02 *(Skip to C3(d))*

(If yes), first name the crop, next the pesticide, then the rate of application. *(If pesticides were applied to more than four crops in 1987, continue listing the crops on the C3 continuation sheet. Also, if more than four pesticides were applied to a crop, continue listing the pesticides that were applied to the crop on the C3 continuation sheet.)*

Crop	1987 Pesticide	Rate (pounds per acre per year)	DK	Active ingredient or Diluted?
1. ____________	1. ____________	|_|_|_|_|	98	A D
	2. ____________	|_|_|_|_|	98	A D
	3. ____________	|_|_|_|_|	98	A D
	4. ____________	|_|_|_|_|	98	A D
Don't know 98	*Don't know* 98			
2. ____________	1. ____________	|_|_|_|_|	98	A D
	2. ____________	|_|_|_|_|	98	A D
	3. ____________	|_|_|_|_|	98	A D
	4. ____________	|_|_|_|_|	98	A D
Don't know 98	*Don't know* 98			
3. ____________	1. ____________	|_|_|_|_|	98	A D
	2. ____________	|_|_|_|_|	98	A D
	3. ____________	|_|_|_|_|	98	A D
	4. ____________	|_|_|_|_|	98	A D
Don't know 98	*Don't know* 98			
4. ____________	1. ____________	|_|_|_|_|	98	A D
	2. ____________	|_|_|_|_|	98	A D
	3. ____________	|_|_|_|_|	98	A D
	4. ____________	|_|_|_|_|	98	A D
Don't know 98	*Don't know* 98			

C3(d). In 1986, were any pesticides used on the crops on the property where the well is located?

Yes 01
No .... 02 *(Skip to C3(e))*

(If yes), first name the crop, next the pesticide, then the rate of application. *(If pesticides were applied to more than four crops in 1986, continue listing the crops on the C3 continuation sheet. Also, if more than four pesticides were applied to a crop, continue listing the pesticides that were applied to the crop on the C3 continuation sheet.)*

Crop	1986 Pesticide	Rate (pounds per acre per year)	DK	Active Ingredient or Diluted?
1. ________	1. ________	_ _ _ _	98	A D
	2. ________	_ _ _ _	98	A D
	3. ________	_ _ _ _	98	A D
	4. ________	_ _ _ _	98	A D
Don't know 98	*Don't know* 98			
2. ________	1. ________	_ _ _ _	98	A D
	2. ________	_ _ _ _	98	A D
	3. ________	_ _ _ _	98	A D
	4. ________	_ _ _ _	98	A D
Don't know 98	*Don't know* 98			
3. ________	1. ________	_ _ _ _	98	A D
	2. ________	_ _ _ _	98	A D
	3. ________	_ _ _ _	98	A D
	4. ________	_ _ _ _	98	A D
Don't know 98	*Don't know* 98			
4. ________	1. ________	_ _ _ _	98	A D
	2. ________	_ _ _ _	98	A D
	3. ________	_ _ _ _	98	A D
	4. ________	_ _ _ _	98	A D
Don't know 98	*Don't know* 98			

C3(e). In 1985, were any pesticides used on the crops on the property where the well is located?

Yes 01
No .... 02 *(Skip to Q C4)*

(If yes), first name the crop, next the pesticide, then the rate of application. *(If pesticides were applied to more than four crops in 1985, continue listing the crops on the C3 continuation sheet. Also, if more than four pesticides were applied to a crop, continue listing the pesticides that were applied to the crop on the C3 continuation sheet.)*

Crop	1985 Pesticide	Rate (pounds per acre per year)	DK	Active Ingredient or Diluted?
1. ________	1. ____________	|_|_|_|_|	98	A D
	2. ____________	|_|_|_|_|	98	A D
	3. ____________	|_|_|_|_|	98	A D
	4. ____________	|_|_|_|_|	98	A D
Don't know 98	*Don't know* 98			
2. ________	1. ____________	|_|_|_|_|	98	A D
	2. ____________	|_|_|_|_|	98	A D
	3. ____________	|_|_|_|_|	98	A D
	4. ____________	|_|_|_|_|	98	A D
Don't know 98	*Don't know* 98			
3. ________	1. ____________	|_|_|_|_|	98	A D
	2. ____________	|_|_|_|_|	98	A D
	3. ____________	|_|_|_|_|	98	A D
	4. ____________	|_|_|_|_|	98	A D
Don't know 98	*Don't know* 98			
4. ________	1. ____________	|_|_|_|_|	98	A D
	2. ____________	|_|_|_|_|	98	A D
	3. ____________	|_|_|_|_|	98	A D
	4. ____________	|_|_|_|_|	98	A D
Don't know 98	*Don't know* 98			

C4. **Approximately how many feet from the well was the closest farm pesticide application area?** *(Enter the distance and circle the code for the unit of measurement.)*

|_|_|_|_|

Feet	01
Yards	02
Other (Specify, ______________)	97
Don't know	98

Box 21

The next few questions are about storage and disposal of farm pesticides on the property where the well is located. When you answer, please do not include pesticides that you used for purposes other than farming.

C5. **Between** January 1, 1985 and the present, have any farm pesticides been stored for more than one month on the property where the well is located? *(Circle one number.)*

Yes 01
No .... 02 } *(Skip to Q C7)*
Don't know .... 98 } *(Skip to Q C7)*

---

a. Starting with 1989, what farm pesticides were stored for more than one month? *(List each pesticide. If more than four pesticides were stored, continue listing the pesticides on the "Generic" continuation sheet.)*

Pesticide
1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Don't know 98
None 99

b. Thinking back to 1988, what farm pesticides were stored for more than one month? *(List each pesticide. If more than four pesticides were stored, continue listing the pesticides on the "Generic" continuation sheet.)*

Pesticide
1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Don't know 98
None 99

c. Thinking back to 1987, what farm pesticides were stored for more than one month? *(List each pesticide. If more than four pesticides were stored, continue listing the pesticides on the "Generic" continuation sheet.)*

Pesticide
1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Don't know 98
None 99

C5. *(continued)*

d. Thinking back to 1986, what farm pesticides were stored for more than one month? *(List each pesticide. If more than four pesticides were stored, continue listing the pesticides on the "Generic" continuation sheet.)*

Pesticide

1. ____________________

2. ____________________

3. ____________________

4. ____________________

Don't know	98
None	99

e. Thinking back to 1985, what farm pesticides were stored for more than one month? *(List each pesticide. If more than four pesticides were stored, continue listing the pesticides on the "Generic" continuation sheet.)*

Pesticide

1. ____________________

2. ____________________

3. ____________________

4. ____________________

Don't know	98
None	99

C6. Approximately how many feet from the well was the closest farm pesticide storage site? *(Enter the distance and circle the code for the unit of measurement.)*

|__|__|__|__|

Feet	01
Yards	02
Other (Specify, ____________) ..	97
Don't know	98

C7. Between January 1, 1985 and the present, have any farm pesticides or pesticide containers been discarded or disposed on the property where the well is located? *(Circle one number.)*

Yes	01	
No	02	*(Skip to Q.C9)*
Don't know	98	*(Skip to Q.C9)*

a. Starting with 1989, what farm pesticides or pesticide containers were disposed? *(List each pesticide. If more than four pesticides were disposed, continue listing the pesticides on the "Generic" continuation sheet.)*

Pesticide

1. ____________________
2. ____________________
3. ____________________
4. ____________________

Don't know	98
None	99

b. Thinking back to 1988, what farm pesticides or pesticide containers were disposed? *(List each pesticide. If more than four pesticides were disposed, continue listing the pesticides on the "Generic" continuation sheet.)*

Pesticide

1. ____________________
2. ____________________
3. ____________________
4. ____________________

Don't know	98
None	99

c. Thinking back to 1987, what farm pesticides or pesticide containers were disposed? *(List each pesticide. If more than four pesticides were disposed, continue listing the pesticides on the "Generic" continuation sheet.)*

Pesticide

1. ____________________
2. ____________________
3. ____________________
4. ____________________

Don't know	98
None	99

C7 *(continued)*

d. Thinking back to 1986, what farm pesticides or pesticide containers were disposed? *(List each pesticide. If more than four pesticides were disposed, continue listing the pesticides on the "Generic" continuation sheet.)*

Pesticide

1. ____________________

2. ____________________

3. ____________________

4. ____________________

Don't know	98
None	99

e. Thinking back to 1985, what farm pesticides or pesticide containers were disposed? *(List each pesticide. If more than four pesticides were disposed, continue listing the pesticides on the "Generic" continuation sheet.)*

Pesticide

1. ____________________

2. ____________________

3. ____________________

4. ____________________

Don't know	98
None	99

C8. Approximately how many feet was the closest farm pesticide disposal site from the well? *(Enter the distance and circle the code for the unit of measurement.)*

|_|_|_|_|

Feet	01
Yards	02
Other (Specify, __________)	97
Don't know	98

C9. **Between January 1, 1985 and the present, has there been an accidental spill of any farm pesticide on the property where the well is located?** *(Circle one number.)*

Yes	01	
No	02	} *(Skip to End)*
Don't know	98	

---

a. Starting with 1989, what farm pesticides were spilled? *(List each pesticide. If more than four pesticides were spilled, continue listing the pesticides on the "Generic" continuation sheet.)*

Pesticide

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

Don't know	98
None	99

b. Thinking back to 1988, what farm pesticides were spilled? *(List each pesticide. If more than four pesticides were spilled, continue listing the pesticides on the "Generic" continuation sheet.)*

Pesticide

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

Don't know	98
None	99

c. Thinking back to 1987, what farm pesticides were spilled? *(List each pesticide. If more than four pesticides were spilled, continue listing the pesticides on the "Generic" continuation sheet.)*

Pesticide

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

Don't know	98
None	99

C9. *(continued)*

d. Thinking back to 1986, what farm pesticides were spilled? *(List each pesticide. If more than four pesticides were spilled, continue listing the pesticides on the "Generic" continuation sheet.)*

Pesticide

1. ____________________
2. ____________________
3. ____________________
4. ____________________

Don't know	98
None	99

e. Thinking back to 1985, what farm pesticides were spilled? *(List each pesticide. If more than four pesticides were spilled, continue listing the pesticides on the "Generic" continuation sheet.)*

Pesticide

1. ____________________
2. ____________________
3. ____________________
4. ____________________

Don't know	98
None	99

C10. Approximately how many feet from the well was the closest farm pesticide spill? *(Enter the distance and circle the code for the unit of measurement.)*

|_|_|_|_|

Feet	01
Yards	02
Other (Specify, __________)	97
Don't know	98

End

I have no further questions. I appreciate your taking the time to participate in this research. In case I need to contact you again, will you please give me your telephone number starting with your area code?

Respondent's telephone number: |_|_|_| |_|_|_| - |_|_|_|_|

Thank you again for your help.

Write the numbers 0-9 in the blanks provided below. Place one number in each blank.

__	__	__	__	__	__	__	__	__	__
0	1	2	3	4	5	6	7	8	9

COMMENTS SHEET

Well ID Number C - ☐☐ - ☐☐ - ☐☐☐☐

A39 Continuation Sheet

WELL # __	WELL # __	WELL # __
a. Is the well open or capped? Open .... 01 Capped .... 02 *Don't know* 98	a. Is the well open or capped? Open .... 01 Capped .... 02 *Don't know* 98	a. Is the well open or capped? Open .... 01 Capped .... 02 *Don't know* 98
b. Is the hole all filled, partially filled, or not filled? All filled .... 01 Partially filled .... 02 Not filled .... 03 *(Skip to the next well)* *Don't know* .... 98 *(Skip to the next well)*	b. Is the hole all filled, partially filled, or not filled? All filled .... 01 Partially filled .... 02 Not filled .... 03 *(Skip to the next well)* *Don't know* .... 98 *(Skip to the next well)*	b. Is the hole all filled, partially filled, or not filled? All filled .... 01 Partially filled .... 02 Not filled .... 03 *(Use A39 Continuation Sheet or skip to Box 12)* *Don't know* .... 98 *(Use A39 Continuation Sheet or skip to Box 12)*
c. What material was used to fill the well hole? *(Specify)* ________________ 01 *(Skip to next well)* *Don't know* .... 98 *(Skip to next well)*	c. What material was used to fill the well hole? *(Specify)* ________________ 01 *(Skip to next well)* *Don't know* .... 98 *(Skip to next well)*	c. What material was used to fill the well hole? *(Specify)* ____________ 01 *(Use A39 Continuation Sheet or skip to Box 12)* *Don't know* ...... 98 *(Use A39 Continuation Sheet or skip to Box 12)*

Well ID Number: C - ☐☐ - ☐☐ - ☐☐☐☐

[illegible] -B2 Continuation Sheet

Enter the year for this continuation sheet: 1 9 __ __

#	Pest	#	1988 Pesticide	Rate (pounds per acre per year)	DK	Active Ingredient or Diluted?
__	______	__	______	_ _ _ _	98	A D
		__	______	_ _ _ _	98	A D
		__	______	_ _ _ _	98	A D
		__	______	_ _ _ _	98	A D
	Don't know 98		*Don't know* 98			
__	______	__	______	_ _ _ _	98	A D
		__	______	_ _ _ _	98	A D
		__	______	_ _ _ _	98	A D
		__	______	_ _ _ _	98	A D
	Don't know 98		*Don't know* 98			
__	______	__	______	_ _ _ _	98	A D
		__	______	_ _ _ _	98	A D
		__	______	_ _ _ _	98	A D
		__	______	_ _ _ _	98	A D
	Don't know 98		*Don't know* 98			
__	______	__	______	_ _ _ _	98	A D
		__	______	_ _ _ _	98	A D
		__	______	_ _ _ _	98	A D
		__	______	_ _ _ _	98	A D
	Don't know 98		*Don't know* 98			

Well ID Number: C - ☐☐ - ☐☐ - ☐☐☐☐

C3 Continuation Sheet

Enter the year for this continuation sheet: 1 9 __ __ Year

Crop		Pesticide		Rate *(pounds per acre per year)*		Active Ingredient or Diluted?
#	Name	#	Name		*DK*	
__	____________	__	________________	__ __ __ __	98	A D
		__	________________	__ __ __ __	98	A D
		__	________________	__ __ __ __	98	A D
		__	________________	__ __ __ __	98	A D
Don't know 98		*Don't know* 98				
__	____________	__	________________	__ __ __ __	98	A D
		__	________________	__ __ __ __	98	A D
		__	________________	__ __ __ __	98	A D
		__	________________	__ __ __ __	98	A D
Don't know 98		*Don't know* 98				
__	____________	__	________________	__ __ __ __	98	A D
		__	________________	__ __ __ __	98	A D
		__	________________	__ __ __ __	98	A D
		__	________________	__ __ __ __	98	A D
Don't know 98		*Don't know* 98				
__	____________	__	________________	__ __ __ __	98	A D
		__	________________	__ __ __ __	98	A D
		__	________________	__ __ __ __	98	A D
		__	________________	__ __ __ __	98	A D
Don't know 98		*Don't know* 98				

Well ID Number C - ☐☐ - ☐☐ - ☐☐☐☐

Generic Continuation Sheet

Place an "X" in the box next to the question for which you are completing this continuation sheet

☐ B4 ☐ B6 ☐ B8 ☐ C5 ☐ C7 ☐ C9

a. Continue listing pesticides for 1989.

Number	Name of Pesticide
___	___
___	___
___	___
___	___

b. Continue listing pesticides for 1988.

Number	Name of Pesticide
___	___
___	___
___	___
___	___

Turn over for years '87, '86, '85

Continuation Sheet

(Years '87, '86, '85)

c. Continue listing pesticides for 1987.

Number	Name of Pesticide
___	______________________________
___	______________________________
___	______________________________
___	______________________________

d. Continue listing pesticides for 1986.

Number	Name of Pesticide
___	______________________________
___	______________________________
___	______________________________
___	______________________________

e. Continue listing pesticides for 1985.

Number	Name of Pesticide
___	______________________________
___	______________________________
___	______________________________
___	______________________________

Form Approved: 3-31-88
OMB No.: 2040-0107
Expires: 4-30-90

Well Identifier

U.S. Environmental Protection Agency
National Pesticide Survey

Local Area
Community Water System Questionnaire

- Script for Scheduling Appointment with County Agent
- Telephone & In-Person Contact (TIC) Record
- Continuation Sheets

August 5, 1988

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL PESTICIDE SURVEY

[illegible] - Script for Scheduling Appointment With County Agent

PLACE RESPONDENT INFORMATION LABEL #3 HERE

Hello, Mr./Ms. *(County Agent's name)*, my name is *(your name)*. I'm with *(your office)* working with the U.S. Environmental Protection Agency on the National Pesticide Survey. The purpose of the Survey is to obtain information on pesticide contamination in drinking water wells and to learn how the pesticides in these wells are associated with pesticide usage and groundwater vulnerability.

The *(name of Community Water System)* Community Water System is participating in this survey, and they have allowed us to sample one of their wells.

I would like to make an appointment with you to ask you some questions about pesticide use and other activities in the area around the well we sampled. Your participation in this survey is voluntary, but we would very much appreciate your cooperation because it is crucial to the success of this project.

When would be the most convenient time for me to visit you during the week of *(indicate sampling week)*? We will also need to look at a map of your county. It would be most helpful if you could have one available at that time.

Would you please give me directions to your location? I will be travelling from *(your location)*.

Thank you for your help with this study. I look forward to seeing you at *(appointment time)*.

NATIONAL PESTICIDE SURVEY

LOCAL AREA COMMUNITY WATER SYSTEM
TELEPHONE & IN-PERSON CONTACT (TIC) RECORD

County Agent Name: ______________________________

County Agent Address: ______________________________

County Agent Telephone Number: |_|_|_| |_|_|_| - |_|_|_|_|

Contact Record					
Date	Start Time	End Time	Your Initials	Result Code	Person Contacted/Comments

Telephone Result Codes

1 = Ring no answer/busy
2 = Refusal
3 = Callback
4 = Not locatable
5 = Scheduled a visit
6 = Other (Specify in Comments, above)

In-Person Result Codes

7 = Respondent unavailable
8 = Substitute respondent
9 = Rescheduled appointment
10 = Refusal/Breakoff
11 = Unlocatable site
12 = Other (Specify in Comments, above)
PC = Partially complete case
C = Complete case

Visit scheduled for: __/__/__/__/ at ______ am/pm

Visit rescheduled for: __/__/__/__/ at ______ am/pm

Interviewer Name: ______________________________

U.S. Environmental Protection Agency
National Pesticide Survey

Local Area Community Water System Questionnaire

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL PESTICIDE SURVEY

LOCAL AREA COMMUNITY WATER SYSTEM QUESTIONNAIRE

Box 1

INTRODUCTION

Hello, Mr./Ms. *(respondent's name)*, my name is *(your name)*. I'm with *(your office)* working with the Environmental Protection Agency on the National Pesticide Survey. I spoke with you *(yesterday or date of conversation)* on the telephone about interviewing you on pesticide use in this area.

As I mentioned, EPA is interested in obtaining information on pesticide contamination of drinking water wells. We are also interested in pesticide usage and groundwater vulnerability in areas that surround the wells.

Before we get started with the interview, I would like to make sure we have recorded your name correctly.

Will you please spell your first and last name?

Respondent name: Mr./Ms. ______________________________
(First name) *(Last name)*

Box 2

This interview is about the area around the *(identify)* well. The well is located near .... *(locate the well on a map and describe the location of the well. Make sure that you and the respondent mutually understand and agree on the 500 acre area that is within one-half mile of the well)*.

The first few questions are about pesticide use in farming in the area within one-half mile of the well. For this survey, we first identify crops that are farmed in the area. Next, we list the pesticides that are used for each crop.

1. Between January 1, 1988 and the present, have any crops been farmed within one-half mile of the well? *(Circle one number.)*

Yes 01
No .... 02 } *(Skip to Q.3, pg.5)*
Don't know .... 98 }

2a. In 1988, were crops farmed within one-half mile of the well? *(Hand the respondent the crop card.)*

Yes 01
No .... 02 *(Skip to 2b)*

(If yes), in 1988, what crops were farmed within one-half mile of the well? *(List all crops in the left-hand column in the table below. If the respondent names more than four crops, continue listing the crops on the "Q2" continuation sheet.)*

In 1988, what pesticides were used on *(name crop #1)*? *(List the pesticides for each crop in the right-hand column of the table. If more than four pesticides were applied to a crop, continue listing the pesticides for the crop on the "Q2" continuation sheet.)*

1988	
Crop	Pesticide
1. ______________	1. ______________ 2. ______________ 3. ______________ 4. ______________ *Don't know* .... 98 *None* 99
2. ______________	1. ______________ 2. ______________ 3. ______________ 4. ______________ *Don't know* .... 98 *None* 99
3. ______________	1. ______________ 2. ______________ 3. ______________ 4. ______________ *Don't know* .... 98 *None* 99
4. ______________	1. ______________ 2. ______________ 3. ______________ 4. ______________ *Don't know* .... 98 *None* 99

2b. In 1987, were crops farmed within one-half mile of the well?

Yes 01
No .... 02 *(Skip to 2c)*

(If yes) In 1987, what crops were farmed within one-half mile of the well? *(List all crops in the left-hand column of the table below. If the respondent names more than four crops, continue listing the crops on the "Q2" continuation sheet.)*

In 1987, what pesticides were used on *(name crop #1)*? *(List the pesticides for each crop in the right-hand column of the table. If more than four pesticides were applied to a crop, continue listing the pesticides for the crop on the "Q2" continuation sheet.)*

1987	
Crop	Pesticide
1. ____________	1. ____________ 2. ____________ 3. ____________ 4. ____________ *Don't know* .... 98 *None* 99
2. ____________	1. ____________ 2. ____________ 3. ____________ 4. ____________ *Don't know* .... 98 *None* 99
3. ____________	1. ____________ 2. ____________ 3. ____________ 4. ____________ *Don't know* .... 98 *None* 99
4. ____________	1. ____________ 2. ____________ 3. ____________ 4. ____________ *Don't know* .... 98 *None* 99

2c. In 1986, were crops farmed within one-half mile of the well?

Yes 01

No .... 02 *(Skip to 3)*

(If yes), in 1986, what crops were farmed within one-half mile of the well? *(List all crops in the left-hand column of the table below. If the respondent names more than four crops, continue listing the crops on the "Q2" continuation sheet.)*

In 1986, what pesticides were used on *(name crop #1)*? *(List the pesticides for each crop in the right-hand column of the table. If more than four pesticides were applied to a crop, continue listing the pesticides for the crop on the "Q2" continuation sheet.)*

1986	
Crop	Pesticide
1. ____________	1. ____________ 2. ____________ 3. ____________ 4. ____________ *Don't know* .... 98 *None* 99
2. ____________	1. ____________ 2. ____________ 3. ____________ 4. ____________ *Don't know* .... 98 *None* 99
3. ____________	1. ____________ 2. ____________ 3. ____________ 4. ____________ *Don't know* .... 98 *None* 99
4. ____________	1. ____________ 2. ____________ 3. ____________ 4. ____________ *Don't know* .... 98 *None* 99

3. Between January 1, 1986 and the present, has any land been used for pasture within one-half mile of the well? *(Circle one number.)*

Yes	01	
No	02	} *(Skip to Q.5)*
Don't know	98	

4. Between January 1, 1986 and the present, what pesticides were used on the pasture?

a. Starting with 1988, what pesticides were used on the pasture? *(List each pesticide. If more than four pesticides were applied, continue listing the pesticides on the "Q4" continuation sheet.)*

Pesticide

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Don't know	98
None	99

b. Thinking back to 1987, what pesticides were used on the pasture? *(List each pesticide. If more than four pesticides were applied, continue listing the pesticides on the "Q4" continuation sheet.)*

Pesticide

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Don't know	98
None	99

c. Thinking back to 1986, what pesticides were used on the pasture? *(List each pesticide. If more than four pesticides were applied, continue listing the pesticides on the "Q4" continuation sheet.)*

Pesticide

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Don't know	98
None	99

Did the respondent use any records to answer the question?

Yes | *No*

5. Between January 1, 1986 and the present, has there been any major non-agricultural pesticide application, such as spraying for gypsy moths or mosquitoes, within one-half mile of the well? *(Circle one number.)*

			Yes	No
Yes	01		1	2
No	02	} *(Skip to Q.7)*		
Don't know	98			

6. Starting with 1988 and thinking back to 1986, what pesticides have been applied? *(For each year, list the pesticides applied. If more than two pesticides were applied in a year, continue listing the pesticides on the "Q6" continuation sheet.)*

	Year	Pesticide	DK	None	Yes	No
a.	1988	______________________________	98	99	1	2
		______________________________	98	99	1	2
b.	1987	______________________________	98	99	1	2
		______________________________	98	99	1	2
c.	1986	______________________________	98	99	1	2
		______________________________	98	99	1	2

Did the respondent use any records to answer the question?

Yes *No*

7. Between January 1, 1986 and the present, has there been an accidental spill of any pesticide within one-half mile of the well? *(Circle one number.)*

Yes .... 01 — 1 2
No .... 02 } *(Skip to Q.9)*
Don't know .... 98 } *(Skip to Q.9)*

8. Starting with 1988 and thinking back to 1986, what pesticides have been spilled? For each pesticide that was spilled, provide the distance between the well and the closest part of the spill. *(For each year, list the pesticides that were spilled. If more than 2 pesticides were spilled in a year, continue listing the pesticides on the "Q8/Q10" continuation sheet.)*

	Year	Pesticide	DK	None	No. Feet From Well	DK	Yes	No
a.	1988	____________	98	99	|_|_|_|_|	98	1	2
		____________	98	99	|_|_|_|_|	98	1	2
b.	1987	____________	98	99	|_|_|_|_|	98	1	2
		____________	98	99	|_|_|_|_|	98	1	2
c.	1986	____________	98	99	|_|_|_|_|	98	1	2
		____________	98	99	|_|_|_|_|	98	1	2

Did the respondent use any records to answer the question?

Yes | *No*

9. Between January 1, 1986 and the present, has there been an accidental spill of any hazardous chemical within one-half mile of the well? *(Circle one number.)* — 1 2

Yes 01
No .... 02 } *(Skip to Q.11)*
Don't know .... 98 }

10. Starting with 1988 and thinking back to 1986, what hazardous chemicals have been spilled? For each chemical that was spilled, provide the distance between the well and the closest part of the spill. *(For each year, list the hazardous chemicals that were spilled. If more than 2 chemicals were spilled in a year, continue listing the chemicals on the "Q8/Q10" continuation sheet.)*

	Year	Hazardous Chemical	DK	None	No. Feet From Well	DK	Yes	No
a.	1988	______________	98	99	|_|_|_|_|	98	1	2
		______________	98	99	|_|_|_|_|	98	1	2
b.	1987	______________	98	99	|_|_|_|_|	98	1	2
		______________	98	99	|_|_|_|_|	98	1	2
c.	1986	______________	98	99	|_|_|_|_|	98	1	2
		______________	98	99	|_|_|_|_|	98	1	2

Did the respondent use any records to answer the question?

Box 3

The next few questions are about facilities located within one-half mile of the well.

11. Within one-half mile of the well is there a . . . *(Read each item and circle a number for each one.)*

		Yes	No	DK	*Yes*	*No*
a.	Chemical plant or storage facility	01	02	98	1	2
b.	Airport	01	02	98	1	2
c.	Military base	01	02	98	1	2
d.	Septic field	01	02	98	1	2
e.	Water disposal pond	01	02	98	1	2
f.	Landfill, including any that are closed	01	02	98	1	2
g.	Municipal or industrial waste treatment facility	01	02	98	1	2
h.	Municipal or other public dump, including any that are closed	01	02	98	1	2
i.	Hazardous waste site, including any that are closed	01	02	98	1	2
j.	Golf course	01	02	98	1	2
k.	Mine, quarry, or gravel pit	01	02	98	1	2
l.	Oil well	01	02	98	1	2
m.	Irrigation or large capacity municipal well	01	02	98	1	2
n.	Pesticide retail outlet	01	02	98	1	2
o.	Grain elevator	01	02	98	1	2

12. Within one-half mile of the well is there a . . . *(Read each item and circle a number for each one.)*

	Yes	No	DK	*Did the respondent use any records to answer the question?* Yes	No
a. Stream, river, creek, or drainage channel	01	02	98	1	2
b. Unlined irrigation canal	01	02	98	1	2
c. Lined irrigation canal	01	02	98	1	2
d. Unlined drainage ditch	01	02	98	1	2
e. Lined drainage ditch	01	02	98	1	2
f. Lined reservoir	01	02	98	1	2
g. Unlined reservoir	01	02	98	1	2
h. Natural lake	01	02	98	1	2
i. Man-made lake	01	02	98	1	2
j. Bay or estuary	01	02	98	1	2
k. Spring	01	02	98	1	2
l. Pond	01	02	98	1	2

13. Is irrigation used within one-half mile of the well? *(Circle one number.)*

			Records Yes	Records No
Yes	01		1	2
No	02	} *(Skip to End)*		
Don't know	98			

14. What irrigation methods are used? *(Read each item and circle a number for each one.)*

	Yes	No	DK	Records Yes	Records No
a. Spray (center pivot, handline, traveling gun, other)	01	02	98	1	2
b. Flood (furrow, ditch, trickle)	01	02	98	1	2
c. Drip	01	02	98	1	2
d. Subsurface	01	02	98	1	2
e. What other *(Specify method)* ____________	01	02	98	1	2

Did the respondent use any records to answer the question?

15. What are the sources of irrigation water? *(Read each item and circle a number for each one.)*

		Yes	No	DK	Yes	No
a.	Groundwater	01	02	98	1	2
b.	Surface water	01	02	98	1	2
c.	Canal	01	02	98	1	2
d.	Spring	01	02	98	1	2
e.	Sewage effluent (primary, secondary, or tertiary)	01	02	98	1	2
f.	What other *(Specify source)* ______________________	01	02	98	1	2

End

I have no further questions. I appreciate your taking the time to participate in this research. In case I need to contact you again, will you please give me your telephone number starting with the area code?

Respondent's telephone number: |__|__|__| |__|__|__| - |__|__|__|__|

Thank you again for your help.

Write the numbers 0-9 in the blanks provided below. Place one number in each blank:

___	___	___	___	___	___	___	___	___	___
0	1	2	3	4	5	6	7	8	9

COMMENTS SHEET

Well ID Number: C - ☐☐ - ☐☐ - ☐☐☐☐

Q2 Continuation Sheet

Place an "X" in the box next to the question for which you are completing this continuation sheet.

☐ Q2a ☐ Q2b ☐ Q2c

Enter the year for this continuation sheet: | 1 | 9 | __ | __ |

#	Crop Name	#	Pesticide Name
__	____________	__	____________
		__	____________
		__	____________
		__	____________
			Don't know 98
__	____________	__	____________
		__	____________
		__	____________
		__	____________
			Don't know 98
__	____________	__	____________
		__	____________
		__	____________
		__	____________
			Don't know 98
__	____________	__	____________
		__	____________
		__	____________
		__	____________
			Don't know 98

Well ID Number: C - ☐☐ - ☐☐ - ☐☐☐☐

Q4 Continuation Sheet

a. Starting with 1988, what pesticides were used on the pasture?

Number	Pesticide
___	___
___	___
___	___
___	___

Don't know 98

b. Thinking back to 1987, what pesticides were used on the pasture?

Number	Pesticide
___	___
___	___
___	___
___	___

Don't know 98

c. Thinking back to 1986, what pesticides were used on the pasture?

Number	Pesticide
___	___
___	___
___	___
___	___

Don't know 98

Well ID Number C - ☐☐ - ☐☐ - ☐☐☐☐

Q6 Continuation Sheet

Year Pesticide

a 1988 ______________________________

____

____

____

____

b 1987 ______________________________

____

____

____

____

c 1986 ______________________________

____

____

____

____

Well ID Number C - ☐☐ - ☐☐ - ☐☐☐☐

Q8/Q10 Continuation Sheet

Place an "X" in the box next to the question for which you are completing this continuation sheet

☐ Q8 ☐ Q10

Year	Pesticide or Hazardous Chemical	DK	No. Feet From Well	DK
a. 1988	______	98	|_|_|_|_|	98
	______	98	|_|_|_|_|	98
	______	98	|_|_|_|_|	98
	______	98	|_|_|_|_|	98
b. 1987	______	98	|_|_|_|_|	98
	______	98	|_|_|_|_|	98
	______	98	|_|_|_|_|	98
	______	98	|_|_|_|_|	98
c. 1986	______	98	|_|_|_|_|	98
	______	98	|_|_|_|_|	98
	______	98	|_|_|_|_|	98
	______	98	|_|_|_|_|	98

U.S. Environmental Protection Agency

National Pesticide Survey

Team Leader Introduction
and
Domestic Well Observation Record

August 24, 1988

Form Approved 3-31-88
OMB No. 2040-0107
Expires 4-30-90

U.S. ENVIRONMENTAL PROTECTION AGENCY

NATIONAL PESTICIDE SURVEY

WELL OBSERVATION RECORD
DOMESTIC WELL

*** August 24, 1988 ***

DOMESTIC WATER SYSTEM SURVEY

WELL OBSERVATION RECORD
DOMESTIC WELL

Observer: ______________________ Well I.D.: D______ - ______ - ______

Respondent:
Name: ______________________
Address: ______________________
Phone Number: ______________________

Interview Record					
Date	Time	Interim Result Code (Number)	Comments	Rescheduled Appointments Date/Time	Final Result Code (Letter)

Telephone Codes

1	No answer
2	Scheduled appointment
3	Confirmed appointment
4	Rescheduled appointment
5	Refused to participate
6	Language Problem
7	Problem (Specify in Comments)

Interim Field Codes

11*	Respondent missed appointment
12*	Respondent cancelled
13	Refusal/Breakoff
14*	Interview not completed
15*	House not located
16	Other problem (Specify in Comments)
*	Schedule another appointment with respondent to complete interview before leaving the county

Final Field Codes

C	Complete
PC	Partial complete
MC	Maximum contact
RB	Refusal/Breakoff
NL	Nonlocatable
LP	Language Problem
I	Ineligible
O	Other (Specify in Comments)

Form Approved 3-31-88
OMB No.. 2040-0107
Expires: 4-30-90

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL PESTICIDE SURVEY

WELL OBSERVATION RECORD
DOMESTIC WELL

Box 1

INTRODUCTION

Hello, Mr./Ms. *(respondent's name)*, my name is *(your name)*. I'm with *(your office)* working with the Environmental Protection Agency on the National Pesticide Survey. I spoke with you *(yesterday or date of conversation)* on the telephone about sampling water from your well. First, I would like to introduce the other members of our survey team, *(name, office)* and *(name, office)*.

For the next hour and a half to two hours, *(name)* and I will be collecting about 30 bottles of water from your well. *(Name)* will interview you about your use of well water.

1. Mr./Mrs. *(respondent's name)*, are you the head of this household or the spouse of head of the household? *(Circle one)*

Head of household	01	
Spouse of head of household	02	
Other	03	*(Thank the respondent for his/her time and ask about the best time to contact either the head of the household or the spouse.)*

2. Before we get started, I would like to make sure we have recorded your name correctly. Will you please spell your first and last name? *(Print respondent's name.)*

Mr./Ms. ____
(First name) *(Last name)*

Box 2

Sampling Orientation

To get started, we would like to look at your well and find a tap from which to take samples of the water. Will you please show us where your well is located? *(At this point examine the well system and determine the appropriate well sampling tap. An appropriate tap would be located before any treatment of the well water.)*

We also need to ask a few questions before we get started.

1. Have you used your water in the past 24 hours for ...

	Yes	No	DK
a. Normal domestic use such as drinking, cooking, bathing, washing dishes, or flushing the toilet?	01	02	98
b. Heavy domestic use such as watering lawns or gardens, washing clothes, cars or equipment, or filling swimming pools?	01	02	98
c. Farm use such as irrigation, watering livestock, washing barns, or processing farm products?	01	02	98

2. Are you using a ...?

	Yes	No	DK
a. Water softener	01	02	98
b. Filter on the well	01	02	98
c. Filter on any faucet	01	02	98
d. Chlorine treatment	01	02	98
e. Activated carbon or charcoal	01	02	98
f. Other treatment *(Specify)* ________________	01	02	98

3. Is there a sanitary or grouted seal protecting the well? *(Circle one number.)*

Yes	01
No	02
Don't know	98

Box 2 continued on next page.

Box 2 (Continued)

4. Is there a pressure or holding tank in the system line? *(Circle one number. If yes, ask the respondent where it is located in relation to the well and make sure the location is recorded in Q.11.)*

Yes	01	
No	02	} *(Skip to Q.6)*
Don't know	98	

5. What is the total capacity of the tank(s)? *(Enter one)*

|__|__|__|__|	Gallons
Don't know	98

6. Do you have a ...? *(For every 'yes' response, ask the respondent where it is located in relation to the well and make sure the location is recorded in Q.12.)*

	Yes	No	DK
a. Septic tank	01	02	98
b. Septic field	01	02	98
c. Cesspool	01	02	98

Box 3

Permission Form

Before we begin sampling, we'd like to get your signature on this EPA permission form. Please review the form while I read it aloud and then ask you to sign it. *(Read the Permission Form aloud, obtain the signature, and give the respondent the original.)*

We can now sample the water from the well. Before we fill the bottles with water, we need to run the water for 15 to 30 minutes to make sure that we are drawing fresh well water and not just stagnant water from a holding tank. While we are doing this, would you like us to direct the water toward or away from anything in particular?

If you wish, you may observe the sampling or proceed with the interview.

WELL OBSERVATION RECORD

1. Which of the following best describes the topographic setting at the well? *(Circle one number.)*

Hilltop	01
Hillside	02
Flat valley	03
Depression	04
Plateau	05
Other *(Specify)* ______________________	06
Don't know	98

2. Is the well closed at the surface, so that water or other liquids cannot enter it from ground level? *(Circle one number.)*

Yes	01
No	02
Don't know	98

3. Which of the following protects the well at the surface?

	Yes	No	DK
a. Well house or shed	01	02	98
b. Concrete pad	01	02	98
c. A covered pit	01	02	98
d. Other *(Specify)* ______________________	01	02	98

4. Which of the following best describes the area within 300 feet of the well . . .? *(Circle one number.)*

Roofed or covered	01
Paved	02
Graveled	03
Exposed or vegetated soil	04
Covered with other material *(Specify material)* ______________________	05
Don't know	98

5. Which of the following best describes the predominant soil condition in the area within 300 feet of the well? *(Circle one number.)*

Sandy/silty	01
Clay	02
Loamy	03
Sandy/loamy	04
Clay/loam	05
Other soil conditions *(Specify)* ______________	06
Don't know	98

6. Which of the following are present in the area within 300 feet of the well?

	Yes	No	DK
a. Drainage ditch	01	02	98
b. Body of water	01	02	98

7. Was the sample obtained before or after treatment? *(Circle one number.)*

Before treatment	01
After treatment	02
Not applicable (no treatment)	03
Don't know	98

8. Is there a pressure or holding tank in the system line? *(Circle one number.)*

Yes	01	
No	02	} *(Skip to Q.11)*
Don't know	98	

9. What is the total capacity of the tank(s)? *(Enter one.)*

|_|_|_|_| Gallons

Don't know 98

10. Was the sample collected before or after the pressure or holding tank(s)? *(Circle one number.)*

Before	01
After	02
Don't know	98

11. Please provide a sketch of the well, associated plumbing, the water delivery system, and any water treatment or holding tanks. On this sketch, please identify with an asterisk (*) exactly where you took samples.

N
↑

SCALE: 1 INCH = ________

12. Survey the area that is within 300 feet of the well. Locate each of the features in the check list. Mark [X] next to each feature present in the area. Sketch and label each feature in the space provided.

X

Well

N ↑

SCALE: 1 INCH = ________

Check list

☐ Well
☐ Drainage ditches
☐ Bodies of water
☐ Septic tanks
☐ Septic fields

☐ Cesspools
☐ Farmland
☐ Cropland
☐ Pasture

☐ Wooded areas
☐ Buildings
☐ Other wells
☐ Paved areas

*** August 24, 1988 ***

Box 4

Write the numbers 0-9 in the blanks provided below. Place one number in each blank:

___	___	___	___	___	___	___	___	___	___
0	1	2	3	4	5	6	7	8	9

COMMENTS SHEET

*** August 24, 1988 ***

U.S. Environmental Protection Agency
National Pesticide Survey

DWS Booklet

Domestic Well Questionnaire

- Domestic Well Interview Record
- Continuation Sheets

Local Area Domestic Well Questionnaire

- Local Area Interview Record
- Continuation Sheets

August 24, 1988

Form Approved 3-31-88
OMB No 2040-0107
Expires 4-30-90

U.S. ENVIRONMENTAL PROTECTION AGENCY

NATIONAL PESTICIDE SURVEY

DOMESTIC WELL QUESTIONNAIRE

*** August 24, 1988 ***

DOMESTIC WATER SYSTEM SURVEY

DOMESTIC WELL INTERVIEW QUESTIONNAIRE

Interviewer ______________ Well I.D. D ______________

Section A
Water Usage
(Head of Sampled Household)
Respondent Name
Address
Phone Number

Section B
Non farm activities
(Person who lives where well is located)
☐ Same as Section A
or
Respondent Name
Address
Phone Number

Section C
Farm Activities
(Farmer)
☐ Same as Section A
or
Respondent Name
Address
Phone Number

Section D
Well construction
(Well Owner)
☐ Same as Section A
or
Respondent Name
Address
Phone Number

Interview Record of Contacts

Date	Time	Section Letter	Interim Result Code (Number)	Comments	Rescheduled Appointments Date/Time	Final Result Code (Letter)

Telephone Codes

1	No answer
2	Scheduled appointment
3	Confirmed appointment
4	Rescheduled appointment
5	Refused to participate
6	Language Problem
7	Problem (Specify in Comments)

Interim Field Codes

11*	Respondent missed appointment
12*	Respondent cancelled
13	Refusal/Breakoff
14*	Interview not completed
15*	House not located
16	Other problem (Specify in Comments)
*	Schedule another appointment with respondent to complete interview before leaving the county

Final Field Codes

C	Complete
PC	Partial complete
MC	Maximum contact
RB	Refusal/Breakoff
NL	Nonlocatable
LP	Language Problem
I	Ineligible
O	Other (Specify in Comments)

*** August 24 1988 ***

SECTION A

Section A contains questions about household use of well water. The questions in Section A must be answered by the head of the sample household or the spouse of the head of the sample household.

Box 1

Has the respondent been introduced to the study?

Yes	01	*[Skip to Box 2]*
No	02	*(Introduction)*

Introduction

Hello, Mr./Ms. ***(respondent's name)***, my name is ***(your name)***. I'm with ***(your office)*** working with the Environmental Protection Agency on the National Pesticide Survey. I spoke with you *(yesterday/date of conversation)* on the telephone about interviewing you on your use of well water.

Mr./Ms. *(respondent's name)*, are you the head of this household or the spouse of the head of the household?

Head of household	01	
Spouse of head of household	02	
Other	03	*(Thank the respondent for his/her time and ask when an eligible respondent is likely to be at home.)*

Before we get started, I would like to make sure we have recorded your name correctly. Will you please spell your first and last name? *(Print the respondent's first and last name.)*

Mr./Ms. ____

(First name) *(Last name)*

Box 2

Mr./Ms. ***(respondent's name)***, the following questions in this interview are about this household and well water usage. *(Ask Q.A1)*

A1. How long have you lived on this property? *(Enter months only if the respondent has lived on the property for less than one year.)*

|__|__| Years

|__|__| Months

Don't know 98

Box 3

The next few questions are about how you and other members of your household use water from the well. For this survey a member of the household is a person for whom this property is the permanent home address. Include all individuals living here who are related or unrelated, who share the address even if they are temporarily away from home.

A2. How many people live in this household?

|__|__| People

Don't know 98

A3. Is the well the main source of household water or is it a secondary source?

Main source	01
Secondary source	02
Don't know	98

A4. Do members of the household use well water for ___? *(Read each of the activities to the respondent.)*

		Yes	No	DK
a.	Drinking	01	02	98
b.	Bathing	01	02	98
c.	Showering	01	02	98
d.	Flushing toilets	01	02	98
e.	Washing dishes	01	02	98
f.	Washing clothes	01	02	98
g.	Swimming	01	02	98
h.	Other major household uses *(Specify)* ____________________	01	02	98

A5. Since January 1, 1986, has the well gone dry?

Yes	01
No	02
Don't know	98

A6. Since January 1, 1986, has there been any accidental contamination due to a backflow of water into the well?

Yes	01	
No	02	} *(Skip to Q A8)*
Don't know	98	

A7 What event caused the backflow of water into the well? In what year?

	Event		Year	
a.	*DK*	98	*DK*	98
b.	*DK*	98	*DK*	98
c.	*DK*	98	*DK*	98
d.	*DK*	98	*DK*	98

A8 Are there times when you have to restrict the amount of water you use from the well?

Yes	01	
No	02	} *[Skip to Box 4]*
Don't know	98	

A9. When do you have to restrict the amount of water you use from the well?

After using large amounts of water	01
During the dry season only	02
When the water is cloudy, sandy, or full of grit	03
Throughout the year	04
Other *(Specify)*	05

Box 4

The next question is about the quality of the well water. We are interested in the water as it is pumped out before it is filtered, before chlorine is added, or before it is treated in any way.

A10. Does the water from the well have any of the following characteristics? *(Read each of the characteristics to the respondent.)*

		Yes	No	DK
a.	Does the water have a color or odor?	01	02	98
b.	Does the water contain sand or grit?	01	02	98
c.	Is the water hard, that is, does it contain a lot of iron or other minerals?	01	02	98
d.	What other characteristic does the water have? *(Specify)* ________________	01	02	98

Box 5

Does the respondent to Section A live on the property where the well is located?

Yes .... *01 [Skip to Box 6]*
No .... *02 (End)*

End

I have no further questions. I appreciate your taking the time to participate in this research. In case I need to contact you again, would you please give me your telephone number starting with your area code?

Respondent's telephone number: (______) ______-____________

Thank you again for your help.

SECTION B

Section B contains questions about how members of the household on the property where the well is located use pesticides for their house, lawn or garden. It also includes questions on the property around the well and on other wells in the vicinity. The questions in Section B must be answered by the head (or spouse) of the household located on the same property as the well. If the sample household and the well are located on different properties, the respondents for Section A and Section B will also be different.

Box 6

Has the respondent been introduced to the study?

Yes	01	*[Skip to Box 7]*
No	02	*(Introduction)*

Introduction

Hello, Mr./Ms. *(respondent's name)*, my name is *(your name)*. I'm with *(your office)* working with the Environmental Protection Agency on the National Pesticide Survey. I spoke with you *(yesterday/date of conversation)* on the telephone about interviewing you on your household, lawn, and garden use of pesticides, and on other features located around the well.

Mr./Ms. *(respondent's name)*, are you the head of this household or the spouse of the head of the household?

Head of household	01	
Spouse of head of household	02	
Other	03	*(Thank the respondent for his/her time and ask when the head of household is likely to be at home.)*

Before we get started, I would like to make sure we have recorded your name correctly. Will you please spell your first and last name? *(Print the respondent's first and last name.)*

Mr./Ms. ____
(First name) *(Last name)*

Box 7

I am going to ask a few questions about how members of your household have used pesticides inside and around the house, on the lawn and in the garden. When answering these questions please do not include pesticides used for farming on the property where the well is located.

B1. **Between January 1, 1986 and the present, have any pesticides been used inside the house?**

Yes 01
No .... 02 } *(Skip to Q B2)*
Don't know .... 98 }

a. Starting with 1988, what pesticides were used in your house?

Pesticide

1. ________________
2. ________________
3. ________________
4. ________________

Don't know 98
None 99

b. Thinking back to 1987, what pesticides were used in your house?

Pesticide

1. ________________
2. ________________
3. ________________
4. ________________

Don't know 98
None 99

c. Thinking back to 1986, what pesticides were used in your house?

Pesticide

1. ________________
2. ________________
3. ________________
4. ________________

Don't know 98
None 99

Use B1-4 Continuation Sheets as needed.

B2. Between January 1, 1986 and the present, have any pesticides been used on the lawn?

Yes	01	
No	02	} *(Skip to Q B3)*
Don't know	98	

a. Starting with 1988, what pesticides were used on the lawn?

Pesticide

1. ______________________
2. ______________________
3. ______________________
4. ______________________

Don't know	98
None	99

b. Thinking back to 1987, what pesticides were used on the lawn?

Pesticide

1. ______________________
2. ______________________
3. ______________________
4. ______________________

Don't know	98
None	99

c. Thinking back to 1986, what pesticides were used on the lawn?

Pesticide

1. ______________________
2. ______________________
3. ______________________
4. ______________________

Don't know	98
None	99

Use B1-4 Continuation Sheets as needed.

B3. **Between** January 1, 1986 and the present, have any pesticides been used on the garden?

Yes 01
No .... 02 } *[Skip to Box 8]*
Don't know .... 98 } *[Skip to Box 8]*

a. Starting with 1988, what pesticides were used on the garden?

Pesticide

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Don't know 98
None 99

b. Thinking back to 1987, what pesticides were used on the garden?

Pesticide

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Don't know 98
None 99

c. Thinking back to 1986, what pesticides were used on the garden?

Pesticide

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Don't know 98
None 99

Use B1-4 Continuation Sheets as needed.

Respondent ID Number: D - ☐☐ - ☐☐ - ☐☐☐☐

B1-4 Continuation Sheet

Place an "X" in the box next to the question for which you are completing this continuation sheet.

☐ B1 ☐ B2 ☐ B3 ☐ B4

a. Continue listing pesticides for 1988.

Number	Name of Pesticide
___	___
___	___
___	___
___	___

b. Continue listing pesticides for 1987.

Number	Name of Pesticide
___	___
___	___
___	___
___	___

c. Continue listing pesticides for 1986.

Number	Name of Pesticide
___	___
___	___
___	___
___	___

Page ____ of ____

Respondent ID Number D - ☐☐ - ☐☐ - ☐☐☐☐

B1-4 Continuation Sheet

Place an "X" in the box next to the question for which you are completing this continuation sheet.

☐ B1 ☐ B2 ☐ B3 ☐ B4

a. Continue listing pesticides for 1988.

Number	Name of Pesticide
___	______________________________
___	______________________________
___	______________________________
___	______________________________

b. Continue listing pesticides for 1987.

Number	Name of Pesticide
___	______________________________
___	______________________________
___	______________________________
___	______________________________

c. Continue listing pesticides for 1986.

Number	Name of Pesticide
___	______________________________
___	______________________________
___	______________________________
___	______________________________

Respondent ID Number D - ☐☐ - ☐☐ - ☐☐☐☐

B1-4 Continuation Sheet

Place an "X" in the box next to the question for which you are completing this continuation sheet

☐ B1 ☐ B2 ☐ B3 ☐ B4

a. Continue listing pesticides for 1988.

Number	Name of Pesticide
___	______________________________
___	______________________________
___	______________________________
___	______________________________

b. Continue listing pesticides for 1987.

Number	Name of Pesticide
___	______________________________
___	______________________________
___	______________________________
___	______________________________

c. Continue listing pesticides for 1986.

Number	Name of Pesticide
___	______________________________
___	______________________________
___	______________________________
___	______________________________

Page ___ of ___

Respondent ID Number D - ☐☐ - ☐☐ - ☐☐☐☐

B1-4 Continuation Sheet

Place an "X" in the box next to the question for which you are completing this continuation sheet

☐ B1 ☐ B2 ☐ B3 ☐ B4

a. Continue listing pesticides for 1988

Number	Name of Pesticide
___	___
___	___
___	___
___	___

b. Continue listing pesticides for 1987

Number	Name of Pesticide
___	___
___	___
___	___
___	___

c. Continue listing pesticides for 1986.

Number	Name of Pesticide
___	___
___	___
___	___
___	___

Box 8

The next few questions are about pesticide storage and disposal. We are interested in pesticides that members of your household may have used inside or around the house, for the lawn or for the garden. When you answer, please do not include pesticides that may have been used for farming.

B4 Between January 1, 1986 and the present, has any member of the household stored any house, lawn, or garden pesticides for more than one month?

Yes	01	
No	02	} (Skip to Q B6)
Don't know	98	

a. Starting with 1988, what pesticides were stored for more than one month?

Pesticide
1. ______________________
2. ______________________
3. ______________________
4. ______________________

Don't know	98
None	99

b. Thinking back to 1987, what pesticides were stored for more than one month?

Pesticide
1. ______________________
2. ______________________
3. ______________________
4. ______________________

Don't know	98
None	99

c. Thinking back to 1986, what pesticides were stored for more than one month?

Pesticide
1. ______________________
2. ______________________
3. ______________________
4. ______________________

Don't know	98
None	99

Use B1-4 Continuation Sheets as needed.

B5. Approximately how many feet from the well was the closest pesticide storage site?

|_|_|_|_|

Feet	01
Yards	02
Other (Specify, ________________)	97
Don't know	98

B6. Since 1986, have any household, lawn, or garden pesticides or pesticide containers been discarded or disposed of on this property?

Yes	01	
No	02	} *(Skip to Q B8)*
Don't know	98	

B7. Approximately how many feet from the well was the closest disposal site?

|_|_|_|_|

Feet	01
Yards	02
Other (Specify, ________________)	97
Don't know	98

B8. Do you have a septic system on this property?

Yes	01	
No	02	} *(Skip to Q B10)*
Don't know	98	

B9. Have you had problems with the septic system during the last year?

Yes	01
No	02
Don't know	98

B10. Do you have a cesspool on this property?

Yes	01	
No	02	} *[Skip to Box 9]*
Don't know	98	

B11. Have you had problems with the cesspool during the last year?

Yes	01
No	02
Don't know	98

Box 9

The next few questions are about other wells in the area. We are interested in wells that are within 500 feet of this well. To give you an idea of the area involved, assume that this well is in the center of a circle having a radius of 500 feet. The circle would contain about 18 acres.

B12. Are there any other operating wells within 500 feet of the well?

Yes 01
No .... 02 } (Skip to Q B14)
Don't know .... 98 }

B13. How many operating wells are within 500 feet of the well?

_ _ _ Operating wells
Don't know 98

B14. Are there any wells that are not operating within 500 feet of the well?

Yes 01
No .... 02 } (Skip to Q B17)
Don't know .... 98 }

B15. How many non-operating wells are within 500 feet of the well?

_ _ _ Wells
Don't know .... 98 (Skip to Q B17)

B16. For every well that is not operating

WE[illegible] #1	WELL #2	WELL #3
a. Is the first well *(Read responses)* Open .... 01 Capped .... 02 *Don't know* 98	a. Is the next well *(Read responses)* Open .... 01 Capped .... 02 *Don't know* 98	a. Is the next well *(Read responses)* Open .... 01 Capped .... 02 *Don't know* 98
b. Is the hole *(Read responses)* All filled .... 01 Partially filled ... 02 Not filled .... 03 *(Skip to Well #2)* *Don't know* 98	b. Is the hole *(Read responses)* All filled .... 01 Partially filled ... 02 Not filled .... 03 *(Skip to Well #3)* *Don't know* 98	b. Is the hole *(Read responses)* All filled .... 01 Partially filled ... 02 Not filled .... 03 *(Use B16 Continuation Sheet or skip to Q.B17)* *Don't know* 98
c. What material was used to fill the well hole? *(Specify)* ________________ 01 *Don't know* 98	c. What material was used to fill the well hole? *(Specify)* ________________ 01 *Don't know* 98	c. What material was used to fill the well hole? *(Specify)* ____________ 01 *(Use B16 Continuation Sheet or skip to Q B17)* *Don't know* 98

B17 Between January 1, 1984 and the present, have you farmed this property?

Yes .... 01 *[Skip to Box 12, pg 19]*
No 02
Don't know 98

B18. Between January 1, 1984 and the present, has anyone else farmed this property?

Yes .... 01 *(Skip to Q B26, pg 18)*
No 02
Don't know 98

Respondent ID Number: D - ☐☐ - ☐☐ - ☐☐☐☐

B16 Continuation Sheet

For every well that is not operating . . .

WELL #1	WELL #2	WELL #3
a. Is the first well . . . *(Read responses)* Open .... 01 Capped .... 02 *Don't know* 98	a. Is the next well . . . *(Read responses)* Open .... 01 Capped .... 02 *Don't know* 98	a. Is the next well . . . *(Read responses)* Open .... 01 Capped .... 02 *Don't know* 98
b. Is the hole . . . *(Read responses)* All filled .... 01 Partially filled .... 02 Not filled .... 03 *(Skip to Well #2)* *Don't know* 98	b. Is the hole . . . *(Read responses)* All filled .... 01 Partially filled .... 02 Not filled .... 03 *(Skip to Well #3)* *Don't know* 98	b. Is the hole . . . *(Read responses)* All filled .... 01 Partially filled .... 02 Not filled .... 03 *(Use B16 Continuation Sheet or skip to Q B17)* *Don't know* 98
c. What material was used to fill the well hole? *(Specify)* ____________________ 01 *Don't know* 98	c. What material was used to fill the well hole? *(Specify)* ____________________ 01 *Don't know* 98	c. What material was used to fill the well hole? *(Specify)* ______________ 01 *(Use B16 Continuation Sheet or skip to Q B17)* *Don't know* 98

Box 10

We are interested in agricultural pesticides that may be prepared for spray applications or stored on this property even if you do not use them on the property. We are referring to pesticides used only for farming.

B19. Between January 1, 1984 and the present, were any agricultural pesticides prepared for spray applications on this property?

Yes	01	
No	02	} (Skip to C B20)
Don't know	98	

a. Starting with 1988, what agricultural pesticides were prepared?

Pesticide

1. ______________________
2. ______________________
3. ______________________
4. ______________________

Don't know	98
None	99

b. Thinking back to 1987, what agricultural pesticides were prepared?

Pesticide

1. ______________________
2. ______________________
3. ______________________
4. ______________________

Don't know	98
None	99

Use Generic Continuation Sheets as needed.

B19. *(continued)*

c. Thinking back to 1986, what agricultural pesticides were prepared?

Pesticide

1. ____
2. ____
3. ____
4. ____

Don't know 98
None 99

d. Thinking back to 1985, what agricultural pesticides were prepared?

Pesticide

1. ____
2. ____
3. ____
4. ____

Don't know 98
None 99

e. Thinking back to 1984, what agricultural pesticides were prepared?

Pesticide

1. ____
2. ____
3. ____
4. ____

Don't know 98
None 99

Use Generic Continuation Sheets as needed.

B20. **Between** January 1, 1984 and the present, were any agricultural pesticides stored on this property for more than one month?

Yes	01	
No	02	*[Skip to Box 11]*
Don't know	98	

a. Starting with 1988, what agricultural pesticides were stored for more than one month?

Pesticide

1. ______
2. ______
3. ______
4. ______

Don't know	98
None	99

b. Thinking back to 1987, what agricultural pesticides were stored for more than one month?

Pesticide

1. ______
2. ______
3. ______
4. ______

Don't know	98
None	99

Use Generic Continuation Sheets as needed.

B20. *(continued)*

c. Thinking back to 1986, what agricultural pesticides were stored for more than one month?

Pesticide

1. ____________________
2. ____________________
3. ____________________
4. ____________________

Don't know	98
None	99

d. Thinking back to 1985, what agricultural pesticides were stored for more than one month?

Pesticide

1. ____________________
2. ____________________
3. ____________________
4. ____________________

Don't know	98
None	99

e. Thinking back to 1984, what agricultural pesticides were stored for more than one month?

Pesticide

1. ____________________
2. ____________________
3. ____________________
4. ____________________

Don't know	98
None	99

Use Generic Continuation Sheets as needed.

Respondent ID Number: D - ☐☐ - ☐☐ - ☐☐☐☐

Generic Continuation Sheet

Place an "X" in the box next to the question for which you are completing this continuation sheet

☐ B19

☐ B20

☐ C10 *(Also enter the quantity applied)*

☐ C12

☐ C15

☐ C18

a. Continue listing pesticides for 1988.

Number	Name of Pesticide
____	________________________________
____	________________________________
____	________________________________
____	________________________________

b. Continue listing pesticides for 1987.

Number	Name of Pesticide
____	________________________________
____	________________________________
____	________________________________
____	________________________________

Turn over for years '84, '85, '86

Continuation Sheet

(Years '84, '85, '86)

c. Continue listing pesticides for 1986.

Number Name of Pesticide

___ ______________________________

___ ______________________________

___ ______________________________

___ ______________________________

d. Continue listing pesticides for 1985.

Number Name of Pesticide

___ ______________________________

___ ______________________________

___ ______________________________

___ ______________________________

e. Continue listing pesticides for 1984.

Number Name of Pesticide

___ ______________________________

___ ______________________________

___ ______________________________

___ ______________________________

B21 Approximately, how many feet from the well was the closest pesticide storage site?

_ _ _ _	Feet	01
	Yards	02
	Other (Specify ____________________)	97
	Don't know	98

Box 11

Did the respondent answer "Yes" to questions B19 (prepared) or B20 (stored)?

Yes	01	*(Continue with Q B22)*
No	02	*(Skip to Q B26)*

B22. Between 1984 and the present, have any agricultural pesticides or pesticide containers been discarded or disposed of on this property?

Yes	01	
No	02	} *(Skip to Q B24)*
Don't know	98	

B23. Approximately how many feet from the well was the closest disposal site?

_ _ _ _	Feet	01
	Yards	02
	Other (Specify ____________________)	97
	Don't know	98

B24. Between 1984 and the present, has there been an accidental spill of any agricultural pesticide on this property?

Yes	01	
No	02	} *(Skip to Q B26)*
Don't know	98	

B25. Approximately how many feet from the well was the closest spill?

|_|_|_|_|	Feet	01
	Yards	02
	Other (Specify ____________________)	97
	Don't know	98

B26. **Are you the owner of the well?**

Yes	01	*[Skip to Box 15, pg 35]*
No	02	} *[End]*
Don't know	98	

End

I have no further questions. I appreciate your taking the time to participate in this research. In case I need to contact you again, would you please give me your telephone number starting with your area code?

Respondent's telephone number: (______) ____________ - ____________________

Thank you again for your help.

SECTION C

Section C contains questions about farming on the property where the well is located. The questions in Section C must be answered by the person who farms the property. The farmer can be a renter, tenant, lessee or the owner of the property where the well is located.

Box 12

Has the respondent been introduced to the study?

Yes	01	*[Skip to Box 13]*
No	02	*(Introduction)*

Introduction

Hello, Mr./Ms. *(respondent's name)*, my name is *(your name)*. I'm with *(your office)* working with the Environmental Protection Agency on the National Pesticide Survey. I spoke with you *(yesterday/date of conversation)* on the telephone about interviewing you on your use of pesticides in farming this property.

Mr./Ms. *(respondent's name)*, do you farm the property located at *(give address and describe the property where the well is located)*?

Yes	01	
No	02	*(Ask who farms the property and ask for the farmer's telephone number. Conclude the interview and call your supervisor.)*
DK	98	

Before we get started, I would like to make sure we have recorded your name correctly. Will you please spell your first and last name? *(Print the respondent's first and last name.)*

Mr./Ms. ____

(First name) *(Last name)*

Box 13

The questions that follow refer to farming on the property where the well is located. Farming is defined as the sale of crops or animals exceeding $1,000 a year.

C1. How many acres do you farm on this property?

|_|_|_|_|_|_| Acres
Don't know 98

C2. Do you use nitrogen fertilizer for farming on this property?

Yes 01
No .... 02 } *[Skip to Box 14]*
Don't know .... 98 }

C3. How much nitrogen fertilizer did you use last year?

|_|_|_|_|_|_| Units
Pounds per acre 01
Kilograms per hectare 02
Don't know 98

C4. Did you store the fertilizer for more than one month on this property?

Yes 01
No .... 02 } *[Skip to Box 14]*
Don't know .... 98 }

C5. Approximately how many feet from the well was the closest fertilizer storage site?

|_|_|_|_|
Feet 01
Yards 02
Other (Specify, ____________________) 97
Don't know 98

Box 14

The next few questions are about pesticide use in farming on this property. We are interested in any chemicals or pesticide products you have used to control insects, weeds, rodents, fungi, or other pests that might damage or harm your crops. Please include any pesticides used in relation to raising farm animals.

C6. Between January 1, 1984 and the present, have you used any pesticides for farming on this property?

Yes 01
No .... 02 } *(Skip to Q.C8, pg. 26)*
Don't know .... 98 }

C7. Starting with 1988 and thinking back to 1984, what pesticides have been used for farming on this property?

First, for 1988, name the crop or animal, next the pesticide, then the rate of application.

(If no pesticides were applied on this property in 1988, check this box: ☐)

Crop/Animal	1988 Pesticide	Rate	Unit of Measure	DK
1. ______	1. ______	____	______	98
	2. ______	____	______	98
	3. ______	____	______	98
	4. ______	____	______	98
Don't know 98	*Don't know* 98			
2. ______	1. ______	____	______	98
	2. ______	____	______	98
	3. ______	____	______	98
	4. ______	____	______	98
Don't know 98	*Don't know* 98			
3. ______	1. ______	____	______	98
	2. ______	____	______	98
	3. ______	____	______	98
	4. ______	____	______	98
Don't know 98	*Don't know* 98			
4. ______	1. ______	____	______	98
	2. ______	____	______	98
	3. ______	____	______	98
	4. ______	____	______	98
Don't know 98	*Don't know* 98			

Use C7 Continuation Sheets as needed.

*** August 24, 1988 ***

C7 *(continued)*

In 1987, what were the crops or animals, pesticides, and rates of application?

(If no pesticides were applied on this property in 1987, check this box: ☐)

Crop/Animal	1987 Pesticide	Rate	Unit of Measure	DK
1. ________	1. ________	____	______	98
	2. ________	____	______	98
	3. ________	____	______	98
	4. ________	____	______	98
Don't know 98	*Don't know* 98			
2. ________	1. ________	____	______	98
	2. ________	____	______	98
	3. ________	____	______	98
	4. ________	____	______	98
Don't know 98	*Don't know* 98			
3. ________	1. ________	____	______	98
	2. ________	____	______	98
	3. ________	____	______	98
	4. ________	____	______	98
Don't know 98	*Don't know* 98			
4. ________	1. ________	____	______	98
	2. ________	____	______	98
	3. ________	____	______	98
	4. ________	____	______	98
Don't know 98	*Don't know* 98			

Use C7 Continuation Sheets as needed.

Respondent ID Number: D - ☐☐ - ☐☐ - ☐☐☐☐

C7 Continuation Sheet

Enter the year for this continuation sheet: | 1 | 9 | ___ | ___ | Year

Crop/Animal		Pesticide			Unit of	
#	Name	#	Name	Rate	Measure	*DK*
___	________	___	________	___	________	98
		___	________	___	________	98
		___	________	___	________	98
		___	________	___	________	98
Don't know 98		*Don't know* 98				
___	________	___	________	___	________	98
		___	________	___	________	98
		___	________	___	________	98
		___	________	___	________	98
Don't know 98		*Don't know* 98				
___	________	___	________	___	________	98
		___	________	___	________	98
		___	________	___	________	98
		___	________	___	________	98
Don't know 98		*Don't know* 98				
___	________	___	________	___	________	98
		___	________	___	________	98
		___	________	___	________	98
		___	________	___	________	98
Don't know 98		*Don't know* 98				

Respondent ID Number D - ☐☐ - ☐☐ - ☐☐☐☐

C7 Continuation Sheet

Enter the year for this continuation sheet: 1 9 ___ ___ Year

Crop/Animal		Pesticide			Unit	
#	Name	#	Name	Rate	of Measure	DK
___	___	___	___	___	___	98
		___	___	___	___	98
		___	___	___	___	98
		___	___	___	___	98
Don't know 98		Don't know 98				
___	___	___	___	___	___	98
		___	___	___	___	98
		___	___	___	___	98
		___	___	___	___	98
Don't know 98		Don't know 98				
___	___	___	___	___	___	98
		___	___	___	___	98
		___	___	___	___	98
		___	___	___	___	98
Don't know 98		Don't know 98				
___	___	___	___	___	___	98
		___	___	___	___	98
		___	___	___	___	98
		___	___	___	___	98
Don't know 98		Don't know 98				

Respondent ID Number D - ☐☐ - ☐☐ - ☐☐☐☐

C7 Continuation Sheet

Enter the year for this continuation sheet: 1 9 __ __ Year

Crop/Animal #	 Name	Pesticide #	 Name	 Rate	Unit of Measure	 DK
__	________	__	________	____	______	98
		__	________	____	______	98
		__	________	____	______	98
		__	________	____	______	98
Don't know 98		*Don't know* 98				
__	________	__	________	____	______	98
		__	________	____	______	98
		__	________	____	______	98
		__	________	____	______	98
Don't know 98		*Don't know* 98				
__	________	__	________	____	______	98
		__	________	____	______	98
		__	________	____	______	98
		__	________	____	______	98
Don't know 98		*Don't know* 98				
__	________	__	________	____	______	98
		__	________	____	______	98
		__	________	____	______	98
		__	________	____	______	98
Don't know 98		*Don't know* 98				

C7. *(continued)*

In 1986, what were the crops or animals, pesticides, and rates of application?

(If no pesticides were applied on this property in 1986, check this box: ☐ *)*

Crop Animal	1986 Pesticide	Rate	Unit of Measure	DK
1. ______	1. ______	____	______	98
	2. ______	____	______	98
	3. ______	____	______	98
	4. ______	____	______	98
Don't know 98	*Don't know* 98			
2. ______	1. ______	____	______	98
	2. ______	____	______	98
	3. ______	____	______	98
	4. ______	____	______	98
Don't know 98	*Don't know* 98			
3. ______	1. ______	____	______	98
	2. ______	____	______	98
	3. ______	____	______	98
	4. ______	____	______	98
Don't know 98	*Don't know* 98			
4. ______	1. ______	____	______	98
	2. ______	____	______	98
	3. ______	____	______	98
	4. ______	____	______	98
Don't know 98	*Don't know* 98			

Use C7 Continuation Sheets as needed.

C7. *(continued)*

In 1985, what were the crops or animals, pesticides, and rates of application?

(If no pesticides were applied on this property in 1985, check this box: ☐ *)*

Crop/Animal	1985 Pesticide	Rate	Unit of Measure	DK
1. ________	1. ________	____	______	98
	2. ________	____	______	98
	3. ________	____	______	98
	4. ________	____	______	98
Don't know 98	*Don't know* 98			
2. ________	1. ________	____	______	98
	2. ________	____	______	98
	3. ________	____	______	98
	4. ________	____	______	98
Don't know 98	*Don't know* 98			
3. ________	1. ________	____	______	98
	2. ________	____	______	98
	3. ________	____	______	98
	4. ________	____	______	98
Don't know 98	*Don't know* 98			
4. ________	1. ________	____	______	98
	2. ________	____	______	98
	3. ________	____	______	98
	4. ________	____	______	98
Don't know 98	*Don't know* 98			

Use C7 Continuation Sheets as needed

Respondent ID Number: D - ☐☐ - ☐☐ - ☐☐☐☐

C7 Continuation Sheet

Enter the year for this continuation sheet: 1 9 __ __ Year

Crop/Animal		Pesticide				
#	Name	#	Name	Rate	Unit of Measure	DK
___	___	___	___	___	___	98
		___	___	___	___	98
		___	___	___	___	98
		___	___	___	___	98
Don't know 98		Don't know 98				
___	___	___	___	___	___	98
		___	___	___	___	98
		___	___	___	___	98
		___	___	___	___	98
Don't know 98		Don't know 98				
___	___	___	___	___	___	98
		___	___	___	___	98
		___	___	___	___	98
		___	___	___	___	98
Don't know 98		Don't know 98				
___	___	___	___	___	___	98
		___	___	___	___	98
		___	___	___	___	98
		___	___	___	___	98
Don't know 98		Don't know 98				

Respondent ID Number: D - ☐☐ - ☐☐ - ☐☐☐☐

C7 Continuation Sheet

Enter the year for this continuation sheet: | 1 | 9 | __ | __ | Year

Crop/Animal		Pesticide			Unit of	
#	Name	#	Name	Rate	Measure	DK
___	___________	___	_________________	___	_____	98
		___	_________________	___	_____	98
		___	_________________	___	_____	98
		___	_________________	___	_____	98
Don't know	98	*Don't know*	98			
___	___________	___	_________________	___	_____	98
		___	_________________	___	_____	98
		___	_________________	___	_____	98
		___	_________________	___	_____	98
Don't know	98	*Don't know*	98			
___	___________	___	_________________	___	_____	98
		___	_________________	___	_____	98
		___	_________________	___	_____	98
		___	_________________	___	_____	98
Don't know	98	*Don't know*	98			
___	___________	___	_________________	___	_____	98
		___	_________________	___	_____	98
		___	_________________	___	_____	98
		___	_________________	___	_____	98
Don't know	98	*Don't know*	98			

C7. *(continued)*

In 1984, what were the crops or animals, pesticides, and rates of application?

(If no pesticides were applied on this property in 1984, check this box: ☐ *)*

Crop/Animal	1984 Pesticide	Rate	Unit of Measure	DK
1. ____	1. ____	____	____	98
	2. ____	____	____	98
	3. ____	____	____	98
	4. ____	____	____	98
Don't know 98	*Don't know* 98			
2. ____	1. ____	____	____	98
	2. ____	____	____	98
	3. ____	____	____	98
	4. ____	____	____	98
Don't know 98	*Don't know* 98			
3. ____	1. ____	____	____	98
	2. ____	____	____	98
	3. ____	____	____	98
	4. ____	____	____	98
Don't know 98	*Don't know* 98			
4. ____	1. ____	____	____	98
	2. ____	____	____	98
	3. ____	____	____	98
	4. ____	____	____	98
Don't know 98	*Don't know* 98			

Use C7 Continuation Sheets as needed.

C8. **Between** January 1, 1984 and the present, have any crops been stored on this property for more than one month?

Yes 01
No .... 02 } (Skip to Q.C11)
Don't know .... 98 }

C9. Between January 1, 1984 and the present, have any farm pesticides been applied to the crops stored on this property?

Yes 01
No .... 02 } (Skip to Q.C11)
Don't know .... 98 }

C10.

a. Starting with 1988, what farm pesticides have been applied to crops stored on this property for more than one month? First name the pesticide and then the amount applied.

	Pesticide	Amount Applied		*Don't know*
		Quantity	Unit of Measure	
1.	______	______	______	98
2.	______	______	______	98
3.	______	______	______	98
4.	______	______	______	98

None 99

b. Thinking back to 1987, what were the pesticides and the amounts applied to crops stored on this property?

	Pesticide	Amount Applied		*Don't know*
		Quantity	Unit of Measure	
1.	______	______	______	98
2.	______	______	______	98
3.	______	______	______	98
4.	______	______	______	98

None 99

Respondent ID Number D - ☐☐ - ☐☐ - ☐☐☐☐

E - Generic Continuation Sheet

Place an "X" in the box next to the question for which you are completing this continuation sheet

☐ B19

☐ B20

☐ C10 *(Also enter the quantity applied)*

☐ C12

☐ C15

☐ C18

a. Continue listing pesticides for 1988.

Number	Name of Pesticide
____	________________________
____	________________________
____	________________________
____	________________________

b. Continue listing pesticides for 1987

Number	Name of Pesticide
____	________________________
____	________________________
____	________________________
____	________________________

Turn over for years '84, '85, '86

Continuation Sheet

(Years '84, '85, '86)

c. Continue listing pesticides for 1986.

Number	Name of Pesticide
___	___
___	___
___	___
___	___

d. Continue listing pesticides for 1985.

Number	Name of Pesticide
___	___
___	___
___	___
___	___

e. Continue listing pesticides for 1984.

Number	Name of Pesticide
___	___
___	___
___	___
___	___

C10. *(continued)*

c. Thinking back to 1986, what were the pesticides and the amounts applied to crops stored on this property?

	Pesticide	Amount Applied		*Don't know*
		Quantity	Unit of Measure	
1.				98
2.				98
3.				98
4.				98

None 99

d. Thinking back to 1985, what were the pesticides and the amounts applied to crops stored on this property?

	Pesticide	Amount Applied		*Don't know*
		Quantity	Unit of Measure	
1.				98
2.				98
3.				98
4.				98

None 99

e. Thinking back to 1984, what were the pesticides and the amounts applied to crops stored on this property?

	Pesticide	Amount Applied		*Don't know*
		Quantity	Unit of Measure	
1.				98
2.				98
3.				98
4.				98

None 99

C11. Between January 1, 1984 and the present, have you stored any farm pesticides for more than one month on this property?

Yes	01	
No	02	} *(Skip to Q C14)*
Don't know	98	

C12.

a. Starting with 1988, what farm pesticides were stored for more than one month? *(Enter the brand name, active ingredient, or type of each pesticide stored.)*

Pesticide
1. ____
2. ____
3. ____
4. ____

Don't know	98
None	99

b. Thinking back to 1987, what farm pesticides were stored for more than one month? *(Enter the brand name, active ingredient, or type of each pesticide stored.)*

Pesticide
1. ____
2. ____
3. ____
4. ____

Don't know	98
None	99

c. Thinking back to 1986, what farm pesticides were stored for more than one month? *(Enter the brand name, active ingredient, or type of each pesticide stored.)*

Pesticide
1. ____
2. ____
3. ____
4. ____

Don't know	98
None	99

Use Generic Continuation Sheets as needed.

Respondent ID Number D - ☐☐ - ☐☐ - ☐☐☐☐

Generic Continuation Sheet

Place an "X" in the box next to the question for which you are completing this continuation sheet

☐ B19

☐ B20

☐ C10 *(Also enter the quantity applied)*

☐ C12

☐ C15

☐ C18

a. Continue listing pesticides for 1988

Number	Name of Pesticide
___	___
___	___
___	___
___	___

b. Continue listing pesticides for 1987

Number	Name of Pesticide
___	___
___	___
___	___
___	___

Turn over for years '84, '85, '86

Continuation Sheet

(Years '84, '85, '86)

c. Continue listing pesticides for 1986.

Number Name of Pesticide

___ ______________________________

___ ______________________________

___ ______________________________

___ ______________________________

d. Continue listing pesticides for 1985.

Number Name of Pesticide

___ ______________________________

___ ______________________________

___ ______________________________

___ ______________________________

e. Continue listing pesticides for 1984.

Number Name of Pesticide

___ ______________________________

___ ______________________________

___ ______________________________

___ ______________________________

C12. *(continued)*

d. Thinking back to 1985, what farm pesticides were stored for more than one month? *(Enter the brand name, active ingredient, or type of each pesticide stored.)*

Pesticide

1. ______

2. ______

3. ______

4. ______

Don't know	98
None	99

e. Thinking back to 1984, what farm pesticides were stored for more than one month? *(Enter the brand name, active ingredient, or type of each pesticide stored.)*

Pesticide

1. ______

2. ______

3. ______

4. ______

Don't know	98
None	99

Use Generic Continuation Sheets as needed.

C13. Approximately how many feet from the well was the closest farm pesticide storage site?

_ _ _ _	Feet	01
	Yards	02
	Other (Specify. ______)	97
	Don't know	98

C14. **Between January 1, 1984 and the present, have any farm pesticides or pesticide containers been discarded or disposed of on this property?**

Yes	01	
No	02	} *(Skip to Q.C17)*
Don't know	98	} *(Skip to Q.C17)*

C15.

a. Starting with 1988, what farm pesticides or pesticide containers were discarded or disposed? *(Enter the brand name, active ingredient, or type of each pesticide or pesticide container(s) disposed.)*

Pesticide
1. ______
2. ______
3. ______
4. ______

Don't know 98
None 99

b. Thinking back to 1987, what farm pesticides or pesticide containers were discarded or disposed? *(Enter the brand name, active ingredient, or type of each pesticide or pesticide container(s) disposed.)*

Pesticide
1. ______
2. ______
3. ______
4. ______

Don't know 98
None 99

c. Thinking back to 1986, what farm pesticides or pesticide containers were discarded or disposed? *(Enter the brand name, active ingredient, or type of each pesticide or pesticide container(s) disposed.)*

Pesticide
1. ______
2. ______
3. ______
4. ______

Don't know 98
None 99

Use Generic Continuation Sheets as needed.

Respondent ID Number D - ☐☐ - ☐☐ - ☐☐☐☐

Generic Continuation Sheet

Place an "X" in the box next to the question for which you are completing this continuation sheet

☐ B19
☐ B20

☐ C10 *(Also enter the quantity applied)*
☐ C12
☐ C15
☐ C18

a. Continue listing pesticides for 1988.

Number	Name of Pesticide
___	___
___	___
___	___
___	___

b. Continue listing pesticides for 1987.

Number	Name of Pesticide
___	___
___	___
___	___
___	___

Turn over for years '84, '85, '86

Continuation Sheet

(Years '84, '85, '86)

c. Continue listing pesticides for 1986.

Number	Name of Pesticide
___	___
___	___
___	___
___	___

d. Continue listing pesticides for 1985.

Number	Name of Pesticide
___	___
___	___
___	___
___	___

e. Continue listing pesticides for 1984.

Number	Name of Pesticide
___	___
___	___
___	___
___	___

C15. *(continued)*

d. Thinking back to 1985, what farm pesticides or pesticide containers were discarded or disposed? *(Enter the brand name, active ingredient, or type of each pesticide or pesticide container(s) disposed.)*

Pesticide

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Don't know 98
None 99

e. Thinking back to 1984, what farm pesticides or pesticide containers were discarded or disposed? *(Enter the brand name, active ingredient, or type of each pesticide or pesticide container(s) disposed.)*

Pesticide

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Don't know 98
None 99

Use Generic Continuation Sheets as needed.

C16. **Approximately how many feet from the well was the closest pesticide disposal site?**

|_|_|_|_|

Feet 01
Yards 02
Other (Specify ______________________) 97
Don't know 98

C17. **Between January 1, 1984 and the present, has there been an accidental spill of any farm pesticide on this property?**

Yes 01
No .... 02 } *(Skip to Q.C20)*
Don't know .... 98 }

C18.

a. Starting with 1988, what farm pesticides were spilled? *(Enter the brand name, active ingredient, or type of each pesticide spilled.)*

Pesticide
1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Don't know 98
None 99

b. Thinking back to 1987, what farm pesticides were spilled? *(Enter the brand name, active ingredient, or type of each pesticide spilled.)*

Pesticide
1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Don't know 98
None 99

c. Thinking back to 1986, what farm pesticides were spilled? *(Enter the brand name, active ingredient, or type of each pesticide spilled.)*

Pesticide
1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Don't know 98
None 99

Use Generic Continuation Sheets as needed.

Respondent ID Number: D - ☐☐ - ☐☐ - ☐☐☐☐

Generic Continuation Sheet

Place an "X" in the box next to the question for which you are completing this continuation sheet.

☐ B19

☐ B20

☐ C10 *(Also enter the quantity applied)*

☐ C12

☐ C15

☐ C18

a. Continue listing pesticides for 1988.

Number	Name of Pesticide
___	___________________
___	___________________
___	___________________
___	___________________

b. Continue listing pesticides for 1987.

Number	Name of Pesticide
___	___________________
___	___________________
___	___________________
___	___________________

Turn over for years '84, '85, '86

Continuation Sheet

(Years '84, '85, '86)

c. Continue listing pesticides for 1986.

Number	Name of Pesticide
___	___
___	___
___	___
___	___

d. Continue listing pesticides for 1985.

Number	Name of Pesticide
___	___
___	___
___	___
___	___

e. Continue listing pesticides for 1984.

Number	Name of Pesticide
___	___
___	___
___	___
___	___

C18. *(continued)*

d. Thinking back to 1985, what farm pesticides were spilled? *(Enter the brand name, active ingredient, or type of each pesticide spilled.)*

Pesticide

1. ____________________
2. ____________________
3. ____________________
4. ____________________

Don't know	98
None	99

e. Thinking back to 1984, what farm pesticides were spilled? *(Enter the brand name, active ingredient, or type of each pesticide spilled.)*

Pesticide

1. ____________________
2. ____________________
3. ____________________
4. ____________________

Don't know	98
None	99

Use Generic Continuation Sheets as needed.

C19. Approximately how many feet from the well was the closest pesticide spill?

|_|_|_|_|

Feet	01
Yards	02
Other (Specify ____________________)	97
Don't know	98

C20. Are there any animals raised on the property for farm purposes?

Yes	01	
No	02	} *(Skip to Q C23)*
Don't know	98	

C21. Which of the following animals are raised? *(Read the responses to the respondent.)*

		Yes	No	DK
a.	Cows	01	02	98
b.	Sheep	01	02	98
c.	Pigs	01	02	98
d.	Horses	01	02	98
e.	Other *(Specify)* ______________________________	01	02	98

C22. Which of the following are the predominant animal husbandry practices? *(Read the responses to the respondent.)*

		Yes	No	DK
a.	Feed lots	01	02	98
b.	Dairy	01	02	98
c.	Grazing	01	02	98
d.	Other *(Specify)* ______________________________	01	02	98

C23. Are you the owner of the well?

Yes	01	*[Skip to Box 15]*
No	02	} *[End]*
Don't know	98	

End

I have no further questions. I appreciate your taking the time to participate in this research. In case I need to contact you again, will you please give me your telephone number starting with your area code?

Respondent's telephone number: (______) ____________ - ____________

Thank you again for your help.

SECTION D

Section D contains questions about the construction of the well. The questions in Section D must be answered by the person who owns the well.

Box 15

Has the respondent been introduced to the study?

Yes	01	*[Skip to Box 16]*
No	02	*(Introduction)*

Introduction

Hello, Mr./Ms. *(respondent's name)*, my name is *(your name)*. I'm with *(your office)* working with the Environmental Protection Agency on the National Pesticide Survey. I spoke with you *(yesterday/date of conversation)* on the telephone about interviewing you on the construction of the well located at *(give address or describe the location of the well)*.

Mr./Ms. *(respondent's name)*, are you the owner of the well?

Yes	01	
No	02	*(Ask who is the well owner and ask for the telephone number. Conclude the interview and call your supervisor.)*
DK	98	

Before we get started, I would like to make sure we have recorded your name correctly. Would you please spell your first and last name? *(Print the respondent's first and last name.)*

Mr./Ms. ______________________________

(First name) *(Last name)*

Box 16

I am going to ask a few questions about the construction of the well. If you have any drilling records or inspection documents they would be helpful.

D1. Including your home, how many separate houses are connected to the well?

|__|__|__| Number of houses

Don't know 98

D2. How many separate businesses are connected to the well?

|__|__|__| Number of businesses

Don't know 98

Did the respondent use any records to answer the question?

Yes | No

D3. In what year was the well originally constructed or drilled?

			Yes	No
1 _ _ _	Year		1	2
Don't know	98			

D4. Since 19___ has the well been redrilled?

			Yes	No
Yes	01		1	2
No	02	*(Skip to Q D6)*		
Don't know	98	*(Skip to Q D6)*		

D5. In what year was the well most recently redrilled?

			Yes	No
1 _ _ _	Year		1	2
Don't know	98			

D6. What is the total depth of the well, that is, what is the total distance from the ground surface to the bottom of the well?

			Yes	No
_ _ _ _	Feet	01	1	2
	Yards	02		
	Other (Specify, ________________)	97		
	Don't know	98		

D7. Is the well drilled into bedrock?

		Yes	No
Yes	01	1	2
No	02		
Don't know	98		

Did the respondent use any records to answer the question?

Yes *No*

Box 17

I would like to ask a few questions about the well casing. *(Show Diagram 1 to the respondent.)* As shown in Diagram 1, a casing is a material that lines the well and prevents it from caving in.

D8. Does the well have a casing?

Yes	01		1	2
No	02	} *[Skip to Box 19]*		
Don't know	98			

D9. Which of the following materials was used to case the well. . .? *(Read the responses to the respondent.)*

		Yes	No	DK		
a.	Plastic pipe (PVC)	01	02	98	1	2
b.	Concrete or cement	01	02	98	1	2
c.	Metal (steel, iron, galvanized metal)	01	02	98	1	2
d.	Tile, brick, or stone	01	02	98	1	2
e.	Other material *(Specify)* ________________	01	02	98	1	2

D10. Is the well cased to its total depth?

Yes	01	*[Skip to Box 18]*	1	2
No	02			
Don't know	98			

D11. What is the total distance from the ground surface to the bottom of the casing?

|_|_|_|_| Feet	01		1	2
Yards	02			
Other (Specify, ________________)	97			
Don't know	98			

Did the respondent use any records to answer the question?

Yes | *No*

Box 18

(Show Diagram 2 to the respondent.) As shown in Diagram 2, some wells have openings or perforations in the side of the casing to allow water to come into the well. These openings are called screens. I would like to ask a few questions about the screens in the well's casing.

D12. Does the well have any screens in the casing?

				Yes	No
Yes	01			1	2
No	02	} *[Skip to Box 19]*			
Don't know	98				

D13. How many screens are in the casing?

				Yes	No
One	01			1	2
Two or more	02	*(Skip to Q.D15)*			
Don't know	98	*[Skip to Box 19]*			

D14. What is the length of the screen?

					Yes	No
|__|__|__|__|	Feet	01	} *[Skip to Box 19]*		1	2
	Yards	02				
	Other (Specify, __________)	97	} *[Skip to Box 19]*			
	Don't know	98				

D15. What is the total distance from the ground surface to the top of the highest screen? *(Show Diagram 3 to explain the distance that you are asking about.)*

				Yes	No
|__|__|__|__|	Feet	01		1	2
	Yards	02			
	Other (Specify, ______________)	97			
	Don't know	98			

Did the respondent use any records to answer the question?

Yes	1
No	2

D16. What is the total distance from the ground surface to the bottom of the deepest screen? *(Use Diagram 3 to explain the distance that you are asking about.).)*

__ __ __ __	Feet	01
	Yards	02
	Other (Specify, ________________)	97
	Don't know	98

Box 19

The next question is about the underground water that flows into the well. *(Give Diagram 4 to the respondent.)* Please look at this sketch. Some areas have a single layer of underground water as shown in Picture A. In other areas, there is a layer of water near the surface, then a layer of soil or rock, then a deeper layer of water as shown in Picture B.

D17 Does Picture A or Picture B better describe the underground water where the well is drilled?

Picture A	01	*[Skip to Box 20]*
Picture B	02	
Don't know	98	*[Skip to Box 20]*

D18. Does the well draw water from the water layer near the surface or from the deeper water layer?

Near surface layer	01
Deeper layer	02
Don't know	98

Box 20

Did the respondent answer "don't know" to any of the following question: D6, D8 through D16?

Yes	01	
No	02	*[Skip to End]*

D19. There were some questions about the construction of your well for which you answered "don't know." Can we contact the company that drilled your well to ask them these questions?

Yes	01	
No, company went out of business	02	} *[Skip to End]*
Don't know the name of company	98	

D20. Can I please have the name, address, and phone number of the company that drilled your well?

Name ____________________

Address ____________________

City ____________________ State __________

Zip Code __________

Phone Number ______ - ______ - __________

End

I have no further questions. I appreciate your taking the time to participate in this research. In case I need to contact you again, will you please give me your telephone number starting with your area code?

Respondent's telephone number: (____) ______ - ________

Thank you again for your help.

Write the numbers 0-9 in the blanks provided below. Place one number in each blank:

__	__	__	__	__	__	__	__	__	__
0	1	2	3	4	5	6	7	8	9

COMMENTS SHEET

Form Approved 3-31-88
OMB No 2040-0107
Expires 4-30-90

U.S. ENVIRONMENTAL PROTECTION AGENCY

NATIONAL PESTICIDE SURVEY

LOCAL AREA DOMESTIC WELL QUESTIONNAIRE

*** August 24, 1988 ***

DOMESTIC WATER SYSTEM SURVEY

LOCAL AREA DOMESTIC WELL QUESTIONNAIRE

Interviewer: ______________________ Well I.D.: D______ - ______ - ______

County Agent
Name
Address
Phone Number

Interview Record					
Date	Time	Interim Result Code (Number)	Comments	Rescheduled Appointments Date/Time	Final Result Code (Letter)

Telephone Codes

1	No answer
2	Scheduled appointment
3	Confirmed appointment
4	Rescheduled appointment
5	Refused to participate
6	Language Problem
7	Problem (Specify in Comments)

Interim Field Codes

11*	Respondent missed appointment
12*	Respondent cancelled
13	Refusal/Breakoff
14*	Interview not completed
15*	House not located
16	Other problem (Specify in Comments)

* Schedule another appointment with respondent to complete interview before leaving the county

Final Field Codes

C	Complete
PC	Partial complete
MC	Maximum contact
RB	Refusal/Breakoff
NL	Nonlocatable
LP	Language Problem
I	Ineligible
O	Other (Specify in Comments)

Form Approved: 3-31-88
OMB No.: 2040-0107
Expires: 4-30-90

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL PESTICIDE SURVEY

LOCAL AREA DOMESTIC WELL QUESTIONNAIRE

Box 1

INTRODUCTION

Hello, Mr./Ms. *(respondent's name)*, my name is *(your name)*. I'm with *(your office)* working with the Environmental Protection Agency on the National Pesticide Survey. I spoke with you *(yesterday or date of conversation)* on the telephone about interviewing you on pesticide use in this area.

As I mentioned, EPA is interested in obtaining information on pesticide contamination of drinking water wells. We are also interested in pesticide usage and groundwater vulnerability in areas that surround the wells.

Before we get started with the interview, I would like to make sure we have recorded your name correctly.

Will you please spell your first and last name?

Respondent name: Mr./Ms. ______________________________
(First name) *(Last name)*

Box 2

This interview is about the area around the *(identify)* well. The well is located near .... *(locate the well on a map and describe the street location of the well. Make sure that you and the respondent mutually understand and agree on the 500 acre area that is within one-half mile of the well).*

The first few questions are about pesticide use in farming in the area within one-half mile of the well. For this survey, we first identify crops that are farmed in the area. Next, we list the pesticides that are used for each crop. *(Ask Q.1)*

1. Between January 1, 1986 and the present, have any crops been farmed within one-half mile of the well?

Yes 01
No .... 02 } *(Skip to Q.3)*
Don't know .... 98 }

*** August 24, 1988 ***

2.a. Starting with 1988, what crops were farmed within one-half mile of the well? *(Hand the respondent the crop card. List all crops in the left-hand column of the table below.)*

In 1988, what pesticides were used on *(name crop #1)*? *(List the pesticides for each crop in the right-hand column of the table.)*

1988	
Crop	Pesticide
1. ________	1. ________ 2. ________ 3. ________ 4. ________ *Don't know* 98
2. ________	1. ________ 2. ________ 3. ________ 4. ________ *Don't know* 98
3. ________	1. ________ 2. ________ 3. ________ 4. ________ *Don't know* 98
4. ________	1. ________ 2. ________ 3. ________ 4. ________ *Don't know* 98

Use Q2 Continuation Sheets as needed.

2.b. Thinking back to 1987, what crops were farmed within one-half mile of the well? *(List all crops in the left-hand column of the table below.)*

In 1987, what pesticides were used on *(name crop #1)*? *(List the pesticides for each crop in the right-hand column of the table.)*

1987	
Crop	Pesticide
1. ____________	1. ____________ 2. ____________ 3. ____________ 4. ____________ *Don't know* 98
2. ____________	1. ____________ 2. ____________ 3. ____________ 4. ____________ *Don't know* 98
3. ____________	1. ____________ 2. ____________ 3. ____________ 4. ____________ *Don't know* 98
4. ____________	1. ____________ 2. ____________ 3. ____________ 4. ____________ *Don't know* 98

Use Q2 Continuation Sheets as needed.

2.c. Thinking back to 1986, what crops were farmed within one-half mile of the well? *(List all crops in the left-hand column of the table below.)*

In 1986, what pesticides were used on *(name crop #1)*? *(List the pesticides for each crop in the right-hand column of the table.)*

1986	
Crop	Pesticide
1. ____________	1. ____________ 2. ____________ 3. ____________ 4. ____________ *Don't know* 98
2. ____________	1. ____________ 2. ____________ 3. ____________ 4. ____________ *Don't know* 98
3. ____________	1. ____________ 2. ____________ 3. ____________ 4. ____________ *Don't know* 98
4. ____________	1. ____________ 2. ____________ 3. ____________ 4. ____________ *Don't know* 98

Use Q2 Continuation Sheets as needed.

Respondent ID Number: D - ☐☐ - ☐☐ - ☐☐☐☐

Q2 Continuation Sheet

Place an "X" in the box next to the question for which you are completing this continuation sheet.

☐ Q2a ☐ Q2b ☐ Q2c

Enter the year for this continuation sheet: | 1 | 9 | ___ | ___ |

#	Crop Name	#	Pesticide Name
___	________________	___	________________
		___	________________
		___	________________
		___	________________
			Don't know 98
___	________________	___	________________
		___	________________
		___	________________
		___	________________
			Don't know 98
___	________________	___	________________
		___	________________
		___	________________
		___	________________
			Don't know 98
___	________________	___	________________
		___	________________
		___	________________
		___	________________
			Don't know 98

Respondent ID Number: D - ☐☐ - ☐☐ - ☐☐☐☐

-Q2 Continuation Sheet

Place an "X" in the box next to the question for which you are completing this continuation sheet.

☐ Q2a ☐ Q2b ☐ Q2c

Enter the year for this continuation sheet: | 1 | 9 | __ | __ |

#	Crop Name	#	Pesticide Name
__	______________	__	______________
		__	______________
		__	______________
		__	______________
			Don't know 98
__	______________	__	______________
		__	______________
		__	______________
		__	______________
			Don't know 98
__	______________	__	______________
		__	______________
		__	______________
		__	______________
			Don't know 98
__	______________	__	______________
		__	______________
		__	______________
		__	______________
			Don't know 98

Respondent ID Number: D - ☐☐ - ☐☐ - ☐☐☐☐

Q2 Continuation Sheet

Place an "X" in the box next to the question for which you are completing this continuation sheet.

☐ Q2a ☐ Q2b ☐ Q2c

Enter the year for this continuation sheet: | 1 | 9 | ___ | ___ |

#	Crop Name	#	Pesticide Name
___	___	___	___
		___	___
		___	___
		___	___
			Don't know 98
___	___	___	___
		___	___
		___	___
		___	___
			Don't know 98
___	___	___	___
		___	___
		___	___
		___	___
			Don't know 98
___	___	___	___
		___	___
		___	___
		___	___
			Don't know 98

3. Between January 1, 1986 and the present, has any land been used for pasture within one-half mile of the well?

Yes 01
No .... 02 } (Skip to Q.5)
Don't know .... 98 } (Skip to Q.5)

4. Between January 1, 1986 and the present, what pesticides were used on the pasture?

a. Starting with 1988, what pesticides were used on the pasture?

Pesticide

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Don't know 98
None 99

b. Thinking back to 1987, what pesticides were used on the pasture?

Pesticide

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Don't know 98
None 99

c. Thinking back to 1986, what pesticides were used on the pasture?

Pesticide

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

Don't know 98
None 99

Use Q4 Continuation Sheets as needed.

Did the respondent use any records to answer the question?

5. Between January 1, 1986 and the present, has there been any major non-agricultural pesticide application, such as spraying for gypsy moths or mosquitoes, within one-half mile of the well?

			Yes	No
Yes	01		1	2
No	02	} *(Skip to Q.7)*		
Don't know	98			

6. Starting with 1988 and thinking back to 1986, what pesticides have been applied?

	Year	Pesticide	*DK*	*None*	Yes	No
a.	1988	______	98	99	1	2
		______	98	99	1	2
b.	1987	______	98	99	1	2
		______	98	99	1	2
c.	1986	______	98	99	1	2
		______	98	99	1	2

Use Q6 Continuation Sheets as needed.

Did the respondent use any records to answer the question?

Yes *No*

7. Between January 1, 1986 and the present, has there been an accidental spill of any pesticide within one-half mile of the well? 1 2

Yes 01
No .... 02 } (Skip to Q 9)
Don't know 98

8. Starting with 1988 and thinking back to 1986, what pesticides have been spilled? How many feet from the well was the closest part of each spill?

	Year	Pesticide	DK	None	No. Feet From Well	DK	Yes	No
a.	1988	______	98	99	|_|_|_|_|	98	1	2
		______	98	99	|_|_|_|_|	98	1	2
b.	1987	______	98	99	|_|_|_|_|	98	1	2
		______	98	99	|_|_|_|_|	98	1	2
c.	1986	______	98	99	|_|_|_|_|	98	1	2
		______	98	99	|_|_|_|_|	98	1	2

Use Q8/Q10 Continuation Sheets as needed.

Did the respondent use any records to answer the question?

Yes ↓ *No* ↓

9. Between January 1, 1986 and the present, has there been an accidental spill of any hazardous chemical within one-half mile of the well?

Yes	01		1	2
No	02	} *(Skip to Q.11)*		
Don't know	98			

10. Starting with 1988 and thinking back to 1986, what hazardous chemicals have been spilled? How many feet from the well was the closest part of each spill?

	Year	Hazardous Chemical	*DK*	*None*	No. Feet From Well	*DK*	*Yes*	*No*
a.	1988	____________________	98	99	|_|_|_|_|	98	1	2
		____________________	98	99	|_|_|_|_|	98	1	2
b.	1987	____________________	98	99	|_|_|_|_|	98	1	2
		____________________	98	99	|_|_|_|_|	98	1	2
c.	1986	____________________	98	99	|_|_|_|_|	98	1	2
		____________________	98	99	|_|_|_|_|	98	1	2

Use Q8/Q10 Continuation Sheets as needed.

Respondent ID Number: D - ☐☐ - ☐☐ - ☐☐☐☐

Q4 Continuation Sheet

a. Starting with 1988, what pesticides were used on the pasture?

Number	Pesticide
___	___
___	___
___	___
___	___

Don't know 98

b. Thinking back to 1987, what pesticides were used on the pasture?

Number	Pesticide
___	___
___	___
___	___
___	___

Don't know 98

c. Thinking back to 1986, what pesticides were used on the pasture?

Number	Pesticide
___	___
___	___
___	___
___	___

Don't know 98

Respondent ID Number: D - ☐☐ - ☐☐ - ☐☐☐☐

Q6 Continuation Sheet

Year	Pesticide
a. 1988	____
	____
	____
	____
	____
b. 1987	____
	____
	____
	____
	____
c. 1986	____
	____
	____
	____
	____

Respondent ID Number: D - ☐☐ - ☐☐ - ☐☐☐☐

Q8/Q10 Continuation Sheet

Place an "X" in the box next to the question for which you are completing this continuation sheet.

☐ Q8 ☐ Q10

	Year	Pesticide or Hazardous Chemical	DK	No. Feet From Well	DK
a.	1988	______	98	|_|_|_|_|	98
		______	98	|_|_|_|_|	98
		______	98	|_|_|_|_|	98
		______	98	|_|_|_|_|	98
b.	1987	______	98	|_|_|_|_|	98
		______	98	|_|_|_|_|	98
		______	98	|_|_|_|_|	98
		______	98	|_|_|_|_|	98
c.	1986	______	98	|_|_|_|_|	98
		______	98	|_|_|_|_|	98
		______	98	|_|_|_|_|	98
		______	98	|_|_|_|_|	98

Did the respondent use any records to answer the question?

Box 3

The next few questions are about the facilities located within one-half mile of the well.

11. Within one-half mile of the well is there a . . . *(Read each item and circle a response for each one.)*

		Yes	No	DK	*Yes*	*No*
a.	Chemical plant or storage facility	01	02	98	1	2
b.	Airport	01	02	98	1	2
c.	Military base	01	02	98	1	2
d.	Septic field	01	02	98	1	2
e.	Water disposal pond	01	02	98	1	2
f.	Landfill, including any that are closed	01	02	98	1	2
g.	Municipal or industrial waste treatment facility	01	02	98	1	2
h.	Municipal or other public dump, including any that are closed	01	02	98	1	2
i.	Hazardous waste site, including any that are closed	01	02	98	1	2
j.	Golf course	01	02	98	1	2
k.	Mine, quarry, or gravel pit	01	02	98	1	2
l.	Oil well	01	02	98	1	2
m.	Irrigation or large capacity municipal well	01	02	98	1	2
n.	Pesticide retail outlet	01	02	98	1	2
o.	Grain elevator	01	02	98	1	2

Did the respondent use any records to answer the question?

12 Within one-half mile of the well is there a *(Read each item and circle a response for each one.)*

		Yes	No	DK	*Yes*	*No*
a.	Stream, river, creek, or drainage channel	01	02	98	1	2
b.	Unlined irrigation canal	01	02	98	1	2
c.	Lined irrigation canal	01	02	98	1	2
d.	Unlined drainage ditch	01	02	98	1	2
e.	Lined drainage ditch	01	02	98	1	2
f.	Lined reservoir	01	02	98	1	2
g.	Unlined reservoir	01	02	98	1	2
h.	Natural lake	01	02	98	1	2
i.	Man-made lake	01	02	98	1	2
j.	Bay or estuary	01	02	98	1	2
k.	Spring	01	02	98	1	2
l.	Pond	01	02	98	1	2

13. Is irrigation used within one-half mile of the well?

Yes	01		1	2
No	02	} *(Skip to End)*		
Don't know	98			

14. What irrigation methods are used?

		Yes	No	DK	*Yes*	*No*
a.	Spray (center pivot, handline, traveling gun, other)	01	02	98	1	2
b.	Flood (furrow, ditch, trickle)	01	02	98	1	2
c.	Drip	01	02	98	1	2
d.	Subsurface	01	02	98	1	2
e.	Other *(Specify method)* ____________________	01	02	98	1	2

15 What are the sources of irrigation water? *(Read each item and circle a response for each one.)*

				Did the respondent use any records to answer the question?	
	Yes	No	DK	Yes	No
a. Groundwater	01	02	98	1	2
b. Surface water	01	02	98	1	2
c. Canal	01	02	98	1	2
d. Spring	01	02	98	1	2
e. Sewage effluent (primary, secondary, or tertiary)	01	02	98	1	2
f. Other *(Specify source)* ____________________	01	02	98	1	2

End

I have no further questions. I appreciate your taking the time to participate in this research. In case I need to contact you again, will you please give me your telephone number starting with the area code?

Respondent's telephone number: ___ ___ ___ ___ ___ ___ - ___ ___ ___ ___

Thank you again for your help.

Write the numbers 0-9 in the blanks provided below. Place one number in each blank:

___ ___ ___ ___ ___ ___ ___ ___ ___ ___
0 1 2 3 4 5 6 7 8 9

COMMENTS SHEET

*** August 24, 1988 ***

National Pesticide Survey

Appendix E: Survey Analytes and Analytical Chemistry Tables

Appendix E: Survey Analytes and Analytical Chemistry Tables

Introduction

Appendix E presents data supplementing the description of the analytes and methods of chemical analysis of NPS well water samples presented in Chapter 4. The tables in this appendix contain data on the following:

- Survey Analytes;
- Minimum Quantification Limits;
- Quality Control Failures;
- Laboratory Control Standards Precision and Accuracy;
- Laboratory Control Standards vs Spiked Field Samples; and
- False Negative Rates.

The analytical results are listed for each analysis method and analyte, and for both the contract and EPA laboratories.

Survey Analytes

Exhibit E-1 provides information about each Survey analyte. The following categories of information are presented. If information is not available for a particular analyte, " — " appears under the appropriate category.

- **Analyte (CAS Registry Number)** – The Survey analyte is listed along with its Chemical Abstracts Service (CAS) Registry Number. CAS is a unique identifier assigned by the American Chemical Society's Chemical Abstracts Service to catalog chemical compounds. CAS Registry Numbers are not available for all Survey analytes.

- **Common and/or Trade Names** – The common name is the name frequently used for the chemical. The trade name is the name under which a product is sold. Many of the Survey analytes are contained in products with several different trade names.

- **Type** – Pesticides are chemicals used to kill, repel, or mitigate pest organisms. Principal types are: herbicides (weeds), insecticides (insects), fungicides (fungi), acaricides (mites, spiders, and ticks), nematocides (nematodes), and rodenticides (rodents).

- **Principal Use** – The particular pests that are killed or controlled by each pesticide, and the types of crops and plants to which it is applied.

- **Regulatory Status** – Pesticide manufacture and use are regulated under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). EPA registers pesticides for specific uses after weighing risks and benefits for each use. The nine categories used to describe the regulatory status of the NPS analytes are:

  - Reregistration (R) - EPA is reevaluating for reregistration existing pesticide active ingredients originally registered prior to current scientific and regulatory standards.

  - Special Review (S) - EPA is aware that this registered pesticide may pose a potential safety problem and is conducting a Special Review, which is an intensive and systematic examination of the risks and benefits of the pesticide. Based on this review, EPA may choose one of several regulatory options, including modifications to the terms and conditions of the registration such as restricting use, changes in packaging, requiring prescribed protective equipment, label warnings, changes in application rates or frequencies, and prohibition against certain types of application methods; or cancellation of some or all uses.

  - Cancellation (C) - EPA has canceled the registration of this pesticide because when used according to widespread and commonly recognized practice, the pesticide generally causes unreasonable adverse effects on the environment, or the registrant(s) elected not to support reregistration of this pesticide.
  - In Process (P) - EPA and/or registrants are involved in activities to determine whether this existing pesticide active ingredient will enter the reregistration process.
  - Not Registered in the United States. (N) - EPA has not registered this pesticide.
  - Degradate (D) - This is a degradate of a registered active ingredient, not an active ingredient itself.
  - Contaminant (T) - This is a contaminant of a registered active ingredient, not a degradate or an active ingredient itself.
  - New Chemical (W) - EPA registered this pesticide active ingredient based on current scientific and regulatory standards.
  - Nitrate (##) is not a pesticide and is not subject to regulation under FIFRA. Nitrate in public water supplies is regulated under the Safe Drinking Water Act.

- **NPS Analytical Method** -- The eight different analytical methods used to determine whether the water samples collected for the Survey contained any of the 127 analytes are as follows:
  - NPS Method 1 - Gas Chromatography with a Nitrogen-Phosphorous Detector (46 nitrogen-phosphorus containing pesticides)
  - NPS Method 2 - Gas Chromatography with an Electron Capture Detector (29 chlorinated pesticides)
  - NPS Method 3 - Gas Chromatography with an Electron Capture Detector (17 chlorinated acid pesticides)
  - NPS Method 4 - High Performance Liquid Chromatography with an Ultraviolet Detector (18 carbonates and related compound pesticides)
  - NPS Method 5 - Direct Aqueous Injection HPLC with Post-Column Derivatization (10 N-methylcarbamoyloxime and N-methylcarbamate pesticides)

- NPS Method 6 - Gas Chromatography with a Nitrogen-Phosphorous Detector (Ethylene thiourea)
- NPS Method 7 - Microextraction and Gas Chromatography (5 pesticides, including EDB and DBPC)
- NPS Method 8 - Purge and Trap Gas Chromatography (volatile organic chemicals) Not Used
- NPS Method 9 - Automated Cadmium Reduction and Colorimetric Detection (Nitrate and nitrite, measured as nitrogen (N))

- **Detected in NPS** – If an analyte was detected at or above the NPS Minimum Reporting Limit or if a qualitative analyte was detected and confirmed to be present during laboratory analysis, a "yes" is listed. If an analyte was not detected, a "no" appears in this column. However, analytes that were not detected may be present in the Survey wells at levels below the NPS Minimum Reporting Limit.

  EPA conducted qualitative analyses for 15 of the 127 analytes. An asterisk (*) appears in this column to signify the qualitative analytes. In some cases these analytes may be detected, but a precise concentration can not be determined for these analytes. In other cases, due to the unreliability of the results of the laboratory method for that analyte and/or the instability of the analyte, it cannot be determined if the analyte is present or not.

- **NPS Minimum Reporting Limit** – The NPS Minimum Reporting Limit (MRL) is the minimum concentration level at which an analyte was reported as having been detected. All analytes except nitrate are reported in micrograms per liter (µg/L), the equivalent of parts per billion (ppb). The analytical method for nitrate analyzed the combined presence of nitrate and nitrite in collected samples and reported the result as nitrogen (N) in mg/L, the equivalent of parts per million (ppm). For the 15 analytes classified as qualitative, "---" appears in this column to signify that there is no designated NPS Minimum Reporting Limit.

- **Lifetime Health Advisory Level** – The Lifetime Health Advisory Level (HAL) represents the maximum concentration of a contaminant in water that may safely be consumed over an average human lifetime. Lifetime Health Advisory Levels are based on health effects that were found in humans or animals given high doses of the chemical in laboratory studies. Health Advisories include a margin of safety to protect human health and should be regarded as guidelines. Health Advisories are based on available scientific data on non-cancer toxic effects. Advisories do not exist for all Survey analytes.

- **Maximum Contaminant Level** -- The Maximum Contaminant Level (MCL), established pursuant to the Safe Drinking Water Act, is the maximum permissible level of a contaminant that is allowed in a public water supply. The date in parenthesis indicates that the MCL was proposed, and provides the date of proposal.

- **Risk Specific Dose at 10^{-6} Cancer Risk** – The Risk Specific Dose (RSD) represents the concentration of a chemical in drinking water which if consumed for a lifetime would result in an excess lifetime cancer risk of one in one million. This assumes that all of the exposure to the chemical is from the drinking water source and a 70 kilogram (150 pound) adult consumes approximately two liters per day of the contaminated water for 70 years.

Minimum Quantification Limits

Exhibit E-2 presents the Minimum Quantification Limits (MQLs) for each analyte and analysis method and for both contract and EPA laboratories. The NPS analytic methods were designed to identify both the presence and concentration of analytes in water samples, whenever possible. For 112 of the 127 analytes, MQLs were established above which a measured concentration was reported. Analytes detected above the MQL were reported with quantification (i.e., at measured concentration). The MQL was used to determine the minimum reporting limit (MRL), established at one-half the MQL. Analytes detected at a concentration between one-half the established MQL and the MQL were reported as detected without a measured concentration.

For 15 analytes that were either unstable or lacked reliable method performance, no reporting limit was established. The confirmed presence of these analytes is reported as "positive detection" without quantification.

Quality Control Failures

Exhibit E-3 presents the numbers of analyses deleted from the Survey due to failure to meet quality control guidelines. In addition to the quality control procedures employed in the laboratories, a series of quality control measures also were implemented for the sample collection and shipping operations. Although in some cases the judgment of the EPA chemist performing final data review did override the formal quality control procedures, generally data that failed to meet the established quality control limits were not used in the analysis of Survey results.

Laboratory Control Standards Precision and Accuracy (10 Times MQL)

Exhibit E-4 presents the results of field samples, fortified at 10 times the MQLs for methods 1-7 and 10 mg/L as nitrogen for method 9, for each analysis method and analyte. To determine the precision and accuracy of chemical analyses, field samples were fortified with the method analytes at the primary laboratories (spiked samples). Approximately 40 field samples were fortified at each of three concentrations: 2, 5, and 10 times the MQL for methods 1-7, and 2 times the MQL, 5 and 10 mg/L as nitrogen, for method 9. The results shown in Exhibit E-4 indicate that excellent precision and accuracy were obtained over the course of the Survey.

Laboratory Control Standards vs. Spiked Field Sample Results (Spiking Level 10 Times MQL)

Exhibit E-5 presents the results of analyses of laboratory control standards, fortified at 10 times the MQL, conducted at both the primary and referee laboratories for each analysis method and analyte. These results were used to assess the relative precision and accuracy obtained at each laboratory. The data shown in Exhibit E-5 indicate that similar precision and accuracy were obtained at both the primary and referee laboratories.

False Negative Rates

Exhibit E-6 presents the results of the comparison of the EPA referee laboratory analyses of each chemical in samples in which this chemical was not observed by the corresponding primary laboratory. Duplicate samples were collected at about 10 percent of the field sites for analysis at the referee laboratories. Taking differences in MQL into account (EPA laboratory MQLs were different from contract laboratory MQLs for many analytes), an analyte detected in the EPA laboratory analysis was not observed at the contract laboratory in only two cases out of 200 samples. The largest false negative rate of these two cases -- atrazine -- was only 0.98 percent. Thus, there was a maximum possible false negative rate of approximately 1 percent or less for each analyte.

Exhibit E-1
National Pesticide Survey Analytes

Analyte (CAS Registry Number)	Common and/or Trade Name(s)	Type	Principal Use	Regulatory Status	NPS Analytical Method	Detected in NPS	NPS Minimum Reporting Limit	Lifetime Health Advisory Level	Maximum Contaminant Level	Risk Specific Dose at 10^{-6} Cancer Risk
Acifluorfen (50594-66-6)	Blazer Carboxyfluorfen Tackle RH-6201	Herbicide	Controls weeds and grasses in soybeans, peanuts, rice, and other large seeded legumes	R	3	*	—	—	—	1 µg/L
Alachlor (15972-60-8)	Lasso	Herbicide	Controls annual grasses and weeds in corn, soybeans, and peanuts	R,S	1	Yes	0.50 µg/L	—	2 µg/L (5/22/89)	0.4 µg/L
Aldicarb (116-06-3)	Temik	Insecticide Acaricide Nematocide	Controls insects, nematodes, and mites on cotton, sugar beets, potatoes, and ornamentals	R,S	5	No	0.71 µg/L	10 µg/L	10 µg/L (5/22/89)	—
Aldicarb sulfone (1646-88-4)	Standak, Aldoxycarb	(See Aldicarb)	(See Aldicarb)	D	5	No	0.62 µg/L	40 µg/L	40 µg/L (5/22/89)	—
Aldicarb sulfoxide (1646-87-3)	(See Aldicarb)	(See Aldicarb)	(See Aldicarb)	D	5	No	0.85 µg/L	10 µg/L	10 µg/L (5/22/89)	—
Aldrin (309-00-2)	HHDN Octalene	Insecticide	Controls soil insects	C	2	No	0.080 µg/L	—	—	—
Ametryn (834-12-8)	Gesapax	Herbicide	Controls weeds in pineapple, sugarcane, bananas, plantains, corn, and potatoes	R	1	No	0.13 µg/L	60 µg/L	—	—
Atraton (1610-17-9)	Gesatamin	Herbicide	Formerly an experimental herbicide	N	1	No	0.17 µg/L	—	—	—
Atrazine (1912-24-9)	AAtrex	Herbicide	Controls certain weeds in corn, sorghum, sugarcane, pineapple, and citrus fruits	R	1	Yes	0.12 µg/L	3 µg/L	3 µg/L (5/22/89)	—
Atrazine, deethylated	(See Atrazine)	(See Atrazine)	(See Atrazine)	D	4	No	2.2 µg/L	—	—	—
Barban (101-27-9)	Carbyne	Herbicide	Controls weeds in wild oats, wheat, lentils, peas, sugar beets, barley, and clover	P	4	No	1.9 µg/L	—	—	—
Baygon (114-26-1)	Propoxur Unden Blattanex	Insecticide	Controls cockroaches, flies, mosquitoes, and turf insects	R	5	No	0.95 µg/L	3 µg/L	—	—

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* Analytes denoted with an asterisk cannot be quantified or reliably detected.

Exhibit E-1 (continued)
National Pesticide Survey Analytes

Analyte (CAS Registry Number)	Common and/or Trade (Names)	Type	Principal Use	Regulatory Status	NPS Analytical Method	Detected in NPS	NPS Minimum Reporting Limit	Lifetime Health Advisory Level	Maximum Contaminant Level	Risk Specific Dose at 10^{-4} Cancer Risk
Bentazon (25057-89-0)	Basagran	Herbicide	Controls broadleaf weeds in soybeans, rice, corn, peanuts, beans, peas, and mint	R	3	Yes	0.25 µg/L	20 µg/L	—	—
Bromacil (314-40-9)	Borea Hyvar Uragan	Herbicide	Controls weeds and brush in non-crop areas, and controls weeds in citrus and pineapple	R	1	No	1.1 µg/L	90 µg/L	—	—
Butachlor (23184-66-9)	Machete	Herbicide	Controls annual grasses and weeds in seeded, transplanted rice and other crops	N	1	No	0.73 µg/L	—	—	—
Butylate (2008-41-5)	Sutan	Herbicide	Controls grassy weeds and nut grass in corn	R	1	No	0.30 µg/L	350 µg/L	—	—
Carbaryl (63-25-2)	Sevin	Insecticide	Controls insects in forests, lawns, ornamentals, shade trees, and rangeland	R	5	No	0.60 µg/L	700 µg/L	—	—
Carbofuran (1563-66-2)	Furadan Curaterr	Insecticide Acaricide Nematocide	Controls insects, mites, nematodes on corn and other crops	R,S	5	No	1.2 µg/L	40 µg/L	40 µg/L (5/22/89)	—
Carbofuran, 3-hydroxy- (———)	(See Carbofuran)	(See Carbofuran)	(See Carbofuran)	D	5	No	1.1 µg/L	—	—	—
Carbofuran, phenol (1563-38-8)	(See Carbofuran)	(See Carbofuran)	(See Carbofuran)	D	4	No	21 µg/L	—	—	—
Carbofuran, phenol, 3-keto- (———)	(See Carbofuran)	(See Carbofuran)	(See Carbofuran)	D	4	No	0.93 µg/L	—	—	—
Carboxin (5234-68-4)	D-735 DCMO Vitavax	Fungicide	Controls smuts on barley, oats, wheat, and seedlings	R	1	No	0.50 µg/L	700 µg/L	—	—
Chloramben (133-90-4)	Amiben Vegiben	Herbicide	Controls weeds in soybeans, peanuts, sunflowers, and corn	C	3	*	—	100 µg/L	—	—

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* Analytes denoted with an asterisk cannot be quantified or reliably detected.

Exhibit E-1 (continued)
National Pesticide Survey Analytes

Analyte (CAS Registry Number)	Common and/or Trade Names	Type	Principal Use	Regulatory Status	NPS Analytical Method	Detected in NPS	NPS Minimum Reporting Limit	Lifetime Health Advisory Level	Maximum Contaminant Level	Risk Specific Dose at 10^{-6} Cancer Risk
alpha-Chlordane (———)	Gold Crest C-100	Insecticide	Controls termites in homes and controls other insects such as fire ants around underground cables	C	2	Yes	0.080 μg/L	—	2 μg/L (5/22/89)	0.03 μg/L
gamma-Chlordane (5566-34-7)	(See alpha-Chlordane)	(See alpha-Chlordane)	(See alpha-Chlordane)	C	2	Yes	0.080 μg/L	—	2 μg/L (5/22/89)	0.03 μg/L
Chlorobenzilate (510-15-6)	Akar Benzilan	Acaricide	Controls mites on citrus, cotton, and vegetables	C	2	*	—	—	—	—
Chloroneb (2675-77-6)	Terraneb	Fungicide	Controls snow mold, and systematic seedling disease of cotton, beans, and soybeans	P	2	No	0.70 μg/L	—	—	—
Chlorothalonil (1897-45-6)	Bravo Daconil	Fungicide	Controls fungus on beans, carrots, celery, corn, conifers, and peanuts	R	2	No	0.080 μg/L	—	—	2 μg/L
Chlorpropham (101-21-3)	Chloro IPC CIPC Furloe Sprout NP	Herbicide	Controls weeds in alfalfa, lima beans, and snap beans	R	1	No	0.35 μg/L	—	—	—
Cyanazine (21725-46-2)	Bladex Fortrol	Herbicide	Controls annual grasses and broadleaf weeds in fallow cropland	R	4	No	2.4 μg/L	10 μg/L	—	—
Cycloate (1134-23-2)	Ro-Neet	Herbicide	Controls annual broadleaf weeds and grasses	R	1	No	0.20 μg/L	—	—	—
2,4-D (94-75-7)	2,4 Dichloro-phenoxyacetic acid Aqua Kleen	Herbicide	Controls weeds in wheat, corn, and barley	R	3	No	0.25 μg/L	70 μg/L	70 μg/L (5/22/89)	—
Dalapon (75-99-0)	Dowpon Ded-Weed	Herbicide	Controls growth of grasses such as quackgrass, bermuda grass, and some perennials	P	3	*	—	200 μg/L	200 μg/L (7/25/90)	—
2,4-DB (94-82-6)	Butyrac Embutox	Herbicide	Controls broadleaf weeds in alfalfa, soybeans, and peanuts	R	3	No	1.0 μg/L	—	—	—

---

* Analytes denoted with an asterisk cannot be quantified or reliably detected.

Exhibit E-1 (continued)
National Pesticide Survey Analytes

Analyte (CAS Registry Number)	Common (and/or Trade) Names	Type	Principal Use	Regulatory Status	NPS Analytical Method	Detected in NPS	NPS Minimum Reporting Limit	Lifetime Health Advisory Level	Maximum Contaminant Level	Risk Specific Dose at 10^{-4} Cancer Risk
DCPA (1861-32-1)	Chlorthal-dimethyl Dacthal	Herbicide	Controls annual grasses in turf, ornamentals, fruit, and vegetables	R	2	No	0.080 µg/L	4,000 µg/L	—	—
DCPA acid metabolites (——)	(See DCPA) Dacthal acid metabolites	(See DCPA)	(See DCPA)	D	3	Yes	0.10 µg/L	4,000 µg/L	—	—
4,4-DDD (72-54-8)	TDE Rothane	Insecticide	Controls mosquitoes and spiders	C	2	No	0.13 µg/L	—	—	—
4,4-DDE (——)	(See 4,4-DDD)	(See 4,4-DDD)	(See 4,4-DDD)	D	2	No	0.080 µg/L	—	—	—
4,4-DDT (——)	(See 4,4-DDD)	(See 4,4-DDD)	(See 4,4-DDD)	C	2	No	0.15 µg/L	—	—	—
Diazinon (333-41-5)	Spectracide Basudin AG-500	Soil Insecticide	Controls insects such as cut worms, wireworms, and maggots on fruit, vegetables, and tobacco	R	1	*	—	0.6 µg/L	—	—
Dibromochloro-propane (DBCP) (96-12-8)	Nemafume Fumazone Nemagon	Soil Fumigant	Controls nematodes on berries, citrus, melons, and nuts	C	7	Yes	0.010 µg/L	—	0.2 µg/L (5/22/89)	0.03 µg/L
Dicamba (1918-00-9)	Banvel D Banlel Compound B Mediben	Herbicide	Controls broadleaf weeds in corn, sorghum, grains, and asparagus	R	3	No	0.10 µg/L	200 µg/L	—	—
Dicamba, 5-hydroxy- (——)	—	Herbicide	Controls annual and perennial broadleaved weed species in asparagus, cereals, grain, and maize	D	3	No	0.10 µg/L	—	—	—
3,5-dichlorobenzoic acid (51-36-5)	Dalapon	Herbicide	Controls perennial grasses	R	3	No	0.30 µg/L	—	—	—
1,2-dichloropropane (78-87-5)	Propylene Dichloride 1,2-DCP	Soil Fumigant	Controls nematodes in soil	T	7	No	0.75 µg/L	—	5 µg/L (5/22/89)	0.6 µg/L

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* Analytes denoted with an asterisk cannot be quantified or reliably detected.

Exhibit E-1 (continued)
National Pesticide Survey Analytes

Analyte (CAS Registry Number)	Common and/or Trade Names	Type	Principal Use	Regulatory Status	NPS Analytical Method	Detected in NPS	NPS Minimum Reporting Limit	Lifetime Health Advisory Level	Maximum Contaminant Level	Risk Specific Dose at 10^{-6} Cancer Risk
cis-1,3-dichloropropene (⊢——⊣)	Telone II	Nematicide	Controls nematodes in soil	R,S	7	No	0.010 µg/L	—	—	0.2 µg/L
trans-1,3-dichloropropene (⊢——⊣)	(See cis-1,3-dichloropropene)	(See cis-1,3-dichloropropene)	(See cis-1,3-dichloropropene)	R,S	7	No	0.10 µg/L	—	—	0.2 µg/L
Dichlorprop (120-36-5)	Cornox RK	Herbicide	Controls polygonum persicaria, galium, and aparine in cereals and pastures	R	3	No	0.26 µg/L	—	—	—
Dichlorvos (62-73-7)	Herkol Nogos Nuvan Phosvit Vapona	Insecticide with fumigant action	Controls mosquitoes, flies, aphids, and spider mites on fruits and vegetables	R,S	1	No	0.12 µg/L	—	—	—
Dieldrin (60-57-1)	Heod Dieldrex Octalox	Insecticide	Controls soil insects such as locusts	C	2	No	0.080 µg/L	—	—	0.002 µg/L
Dinoseb (88-85-7)	DNBP Dinitro Premerge	Herbicide	Controls potato vines and desiccating seed crops	C	3	Yes	1.3 µg/L	7 µg/L	7 µg/L (7/25/90)	—
Diphenamid (957-51-7)	Dymid Enide	Herbicide	Controls annual grasses and broadleaf weeds in peanuts, tobacco and alfalfa	P	1	No	0.22 µg/L	200 µg/L	—	—
Disulfoton (298-04-4)	Dysyston Dithiodemeton Di-syston Dithio-systox	Insecticide	Controls insects and mites on seeds	R	1	*	—	0.3 µg/L	—	—
Disulfoton sulfone (2497-06-5)	(See Disulfoton)	(See Disulfoton)	(See Disulfoton)	D	1	*	—	—	—	—
Disulfoton sulfoxide (2497-07-6)	(See Disulfoton)	(See Disulfoton)	(See Disulfoton)	D	1	*	—	—	—	—

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Exhibit E-1 (continued)
National Pesticide Survey Analytes

Analyte (CAS Registry Number)	Common or Trade Name(s)	Type	Principal Use	Regulatory Status	NPS Analytical Method	Detected in NPS	NPS Minimum Reporting Limit	Lifetime Health Advisory Level	Maximum Contaminant Level	Risk Specific Dose at 10⁻⁶ Cancer Risk
Diuron (330-54-1)	DCMU Karmex	Herbicide	Controls broadleaf and grassy weeds in wheat, barley, and bananas	R	4	No	0.32 µg/L	10 µg/L	—	—
Endosulfan I (——)	Thiodan Cyclodan Malix	Insecticide Acaricide	Controls a variety of insects such as mites on cereals, coffee, cotton, fruit, oilseeds, potatoes, and tea	D	2	No	0.080 µg/L	—	—	—
Endosulfan II (——)	(See Endosulfan I)	(See Endosulfan I)	(See Endosulfan I)	D	2	No	0.13 µg/L	—	—	—
Endosulfan sulfate (1031-07-8)	(See Endosulfan I)	(See Endosulfan I)	(See Endosulfan I)	D	2	No	0.13 µg/L	—	—	—
Endrin (72-20-8)	Hendrin	Insecticide	Controls insects on cotton, small grains, and grasshoppers in noncrop areas	C	2	No	0.13 µg/L	2 µg/L	2 µg/L (7/25/90)	—
Endrin aldehyde (7421-93-4)	(See Endrin)	(See Endrin)	(See Endrin)	D	2	No	0.13 µg/L	—	—	—
EPTC (759-94-4)	EPTAM	Herbicide	Controls weeds in beans, potatoes, and corn	R	1	No	0.15 µg/L	—	—	—
Ethoprop (13194-48-4)	Mocap Prophos Ethoprophos	Nematicide Insecticide	Controls nematodes and insects on bananas, cabbage, and corn	R	1	No	0.080 µg/L	—	—	—
Ethylene dibromide (EDB) (106-93-4)	Bromofume Nephis	Insecticide	Controls insects in soil and is an additive in leaded gasoline	C	7	Yes	0.010 µg/L	—	0.05 µg/L (5/22/89)	0.0004 µg/L
Ethylene thiourea (ETU) (96-45-7)	ETU	Breakdown product of EBDC Fungicides	EBDC controls fungus on roses and other flowers, potatoes, tomatoes, lettuce, and apples	D	6	Yes	4.5 µg/L	—	—	0.2 µg/L
Etridiazole (2593-15-9)	Koban Terrazole	Soil Fungicide	Controls diseases of turf, beans, corn, cotton, and sorghum	R	2	No	0.13 µg/L	—	—	—

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Exhibit E-1 (continued)
National Pesticide Survey Analytes

Analyte (CAS Registry Number)	Common and/or Trade Names	Type	Principal Use	Regulatory Status	NPS Analytical Method	Detected in NPS	NPS Minimum Reporting Limit	Lifetime Health Advisory Level	Maximum Contaminant Level	Risk Specific Dose at 10^{-6} Cancer Risk
Fenamiphos (22224-92-6)	Nemacur Ironmoury	Insecticide Nematicide	Controls nematodes and insects on cotton, peanuts, soybeans, vegetables, and fruit	R	1	No	0.15 µg/L	2 µg/L	—	—
Fenamiphos sulfone (———)	(See Fenamiphos)	(See Fenamiphos)	(See Fenamiphos)	D	4	No	29 µg/L	—	—	—
Fenamiphos sulfoxide (———)	(See Fenamiphos)	(See Fenamiphos)	(See Fenamiphos)	D	4	No	4.7 µg/L	—	—	—
Fenarimol (60168-88-9)	Bloc Rimidin Rubigan	Fungicide	Protects against powdery mildew on apples, grapes, and roses	R	1	No	0.20 µg/L	—	—	—
Fluometuron (2164-17-2)	Cotoran C-2059	Herbicide	Controls annual grasses, and broadleaf weeds	R	4	No	0.46 µg/L	90 µg/L	—	—
Fluridone (59756-60-4)	Sonar	Herbicide	Controls annual grass and weeds in cotton fields	W	1	No	0.90 µg/L	—	—	—
alpha-HCH (319-84-6)	(See gamma-HCH)	(See gamma-HCH)	(See gamma-HCH)	C	2	No	0.080 µg/L	—	—	—
beta-HCH (319-85-7)	(See gamma-HCH)	(See gamma-HCH)	(See gamma-HCH)	C	2	Yes	0.080 µg/L	—	—	—
delta-HCH (319-86-8)	(See gamma-HCH)	(See gamma-HCH)	(See gamma-HCH)	C	2	*	—	—	—	—
gamma-HCH (58-89-9)	gamma BHC (Lindane)	Insecticide	Controls leafhoppers in lowland rice and beetles in wood	C	2	Yes	0.043 µg/L	0.2 µg/L	0.2 µg/L (5/22/89)	0.03 µg/L
Heptachlor (76-44-8)	Velsicol 3-chlorochlorene	Insecticide	Controls insects on corn, alfalfa, hay, and vegetables	C	2	No	0.080 µg/L	—	0.4 µg/L (5/22/89)	0.008 µg/L
Heptachlor epoxide (1024-57-3)	(See Heptachlor)	(See Heptachlor)	(See Hepatchlor)	D	2	No	0.080 µg/L	—	0.2 µg/L (5/22/89)	0.004 µg/L
Hexachlorobenzene (118-74-1)	Anti-Carie HCB	Fungicide	Controls fungus on wheat	C,T	2	Yes	0.080 µg/L	—	1 µg/L (7/25/90)	0.02 µg/L

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Exhibit E-1 (continued)
National Pesticide Survey Analytes

Analyte (CAS Registry Number)	Common Trade Name(s)	Type	Principal Use	Regulatory Status	NPS Analytical Method	Detected in NPS	NPS Minimum Reporting Limit (MRL)	Lifetime Health Advisory Level	Maximum Contaminant Level	Risk Specific Dose at 10⁻⁶ Cancer Risk
Hexazinone (51235-04-2)	Velpar	Herbicide	Controls selective weeds in conifers, sugarcane, pineapple, and pecans	R	1	No	0.14 µg/L	200 µg/L	—	—
Linuron (330-55-2)	Afalon	Herbicide	Controls weeds in field corn, carrots, celery, and potatoes	R	4	No	0.46 µg/L	—	—	—
Merphos (150-50-5)	Folex	Defoliant	Acts as a cotton defoliant	P	1	*	—	—	—	—
Methiocarb (2032-65-7)	Mesurol Draza	Insecticide	Controls insects on cherries, and acts as a bird repellent on cherries	R	5	No	1.8 µg/L	—	—	—
Methomyl (16752-77-5)	Lannate Nudrin	Insecticide	Controls a broad-spectrum of insects on agricultural and ornamental crops	R	5	No	0.60 µg/L	200 µg/L	—	—
Methoxychlor (72-43-5)	Malate DMDT Methoxy-DDT	Insecticide	Controls insects on fruit and shade trees	R	2	No	0.30 µg/L	400 µg/L	400 µg/L (5/22/89)	—
Methyl paraoxon (950-35-6)	E-600 Mintacol	Insecticide	Controls a variety of insects	R	1	No	0.15 µg/L	—	—	—
Metolachlor (51218-45-2)	Dual Primextra	Herbicide	Controls weeds in woody ornamentals, sunflowers, and corn	R	1	No	0.75 µg/L	100 µg/L	—	—
Metribuzin (21087-64-9)	Sencor Sencorex Lexone	Herbicide	Controls grass and broadleaf weeds in soybeans, wheat, barley, peas, and lentils	R	1	No	0.15 µg/L	200 µg/L	—	—
Metribuzin DA (35045-02-4)	(See Metribuzin)	(See Metribuzin)	(See Metribuzin)	D	4	No	0.60 µg/L	—	—	—
Metribuzin DADK (——)	(See Metribuzin)	(See Metribuzin)	(See Metribuzin)	D	4	*	—	—	—	—
Metribuzin DK (——)	(See Metribuzin)	(See Metribuzin)	(See Metribuzin)	D	4	*	—	—	—	—

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Exhibit E-1 (continued)
National Pesticide Survey Analytes

Analyte (CAS Registry Number)	Common and/or Trade Names	Type	Principal Use	Regulatory Status	NPS Analytical Method	Detected in NPS	NPS Minimum Reporting Limit	Lifetime Health Advisory Level	Maximum Contaminant Level	Risk Specific Dose at 10^{-6} Cancer Risk
Mevinphos (7786-34-7)	Phosdrin	Insecticide Acaricide	Controls mites, beetles, grasshoppers, cutworms and leafhoppers on a broad range of vegetables and fruit	R	1	No	0.16 µg/L	—	—	—
MGK 264 (113-48-4)	Van Dyke-264	Synergist	Acts as a synergist for pyrethrin, allethrin, and rotenone	R	1	No	1.0 µg/L	—	—	—
Molinate (2212-67-1)	Ordram	Herbicide	Controls germinating broad-leaves and watergrass in rice	R	1	No	0.16 µg/L	—	—	—
Napropamide (15299-99-7)	Devrinol	Herbicide	Controls annual grasses and broadleaf weeds	R	1	No	0.25 µg/L	—	—	—
Neburon (555-37-3)	Kloben	Herbicide	Controls weeds and grasses in nursery, ornamentals	R	4	No	0.30 µg/L	—	—	—
Nitrate (14797-55-8)	—	Fertilizer	Acts as an inorganic fertilizer	##	9	Yes	0.15 mg/L	10 mg/L	10 mg/L (5/22/89)	—
4-Nitrophenol (100-02-7)	—	Fungicide Breakdown product of parathion insecticides	Degradate of parathion pesticides, controls a variety of insects such as aphids and mosquitoes on pears and apples	D,R	3	* Yes	—	60 µg/L	—	—
Norflurazon (27314-13-2)	Zorial Evital Solicam	Herbicide	Controls insects on cotton, stone fruits, nuts, and cranberries	R	1	No	0.16 µg/L	—	—	—
Oxamyl (23135-22-0)	Vydate DPX-1410	Insecticide	Controls insects, mites, and nematodes on crops and fruits	R	5	No	0.86 µg/L	200 µg/L	200 µg/L (7/25/90)	—
Pentachlorophenol (PCP) (87-86-5)	Dowicide 7	Fungicide Insecticide Defoliant Herbicide	Protects timber from fungal rots and insects	R,S	3	No	0.10 µg/L	200 µg/L	200 µg/L (5/22/89)	0.01 µg/L

Exhibit E-1 (continued)
National Pesticide Survey Analytes

Analyte (CAS Registry Number)	Common Trade Name(s)	Type	Principal Use	Regulatory Status	NPS Analytical Method	Detected in NPS	NPS Minimum Reporting Limit	Lifetime Health Advisory Level	Maximum Contaminant Level	Risk Specific Dose at 10^{-6} Cancer Risk
Pebulate (1114-71-2)	Tillam	Herbicide	Controls annual grasses, nut sedge, and broadleaf weeds in sugar beets, tobacco, and tomatoes	R	1	No	0.19 µg/L	—	—	—
cis-Permethrin (61949-76-6)	Ambush Perthrine	Insecticide	Controls a broad range of insects in cotton	R	2	No	0.50 µg/L	—	—	—
trans-Permethrin (61949-77-7)	(See cis-Permethrin)	(See cis-Permethrin)	(See cis-Permethrin)	R	2	No	2.0 µg/L	—	—	—
Picloram (1918-02-1)	Tordon	Herbicide	Controls broadleaf and woody plants in pastures and rangeland	R	3	No	0.50 µg/L	500 µg/L	500 µg/L (7/25/90)	—
Prometon (1610-18-0)	Gesagram	Herbicide	Controls perennials, broadleaf weeds, and grasses in non-crop areas	R	1	Yes	0.15 µg/L	100 µg/L	—	—
Prometryn (7287-19-6)	Gesagard Caparol	Herbicide	Controls weeds in cotton, peas, carrots, and vegetables	R	1	No	0.10 µg/L	—	—	—
Pronamide (23950-58-5)	Kerb	Herbicide	Controls weeds and grass in lettuce, legumes, and trees	R	1	*	—	50 µg/L	—	—
Pronamide metabolite (N-(1,1-dimethylacetonyl)-3,5-dichlorobenzamide) (——)	(See Pronamide)	(See Pronamide)	(See Pronamide)	D	4	No	3.1 µg/L	—	—	—
Propachlor (1918-16-7)	Bexton Ramrod	Herbicide	Controls grasses and certain broadleaf weeds	R	2	No	0.65 µg/L	90 µg/L	—	—
Propanil (709-98-8)	Rogue	Herbicide	Controls weeds in rice and potatoes	R	4	No	0.30 µg/L	—	—	—
Propazine (139-40-2)	Gesamil Milogard Primatol P	Herbicide	Controls annual broadleaf weeds and grasses in sorghum	C	1	No	0.10 µg/L	10 µg/L	—	—

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Exhibit E-1 (continued)
National Pesticide Survey Analytes

Analyte (CAS Registry Number)	Common and/or Trade Names	Type	Principal Use	Regulatory Status	NPS Analytical Method	Detected in NPS	NPS Minimum Reporting Limit	Lifetime Health Advisory Level	Maximum Contaminant Level	Risk Specific Dose at 10^{-6} Cancer Risk
Propham (122-42-9)	IPC Beet-Kleen	Herbicide	Controls weeds in alfalfa, lettuce, spinach, sugar beets, lentils, and peas	C	4	No	5.5 µg/L	100 µg/L	—	—
Simazine (122-34-9)	Princep Aquazine Gesatop Weedex	Herbicide	Controls annual grasses and weeds in crops, especially corn, and fruit such as citrus, asparagus, and nuts	R	1	Yes	0.38 µg/L	1 µg/L	1 µg/L (7/25/90)	—
Simetryn (1014-70-6)	Gy-bon	Herbicide	Controls broadleaf weeds in rice	N	1	No	0.050 µg/L	—	—	—
Stirofos (22248-79-9)	Gardona Tetrachlorvinphos	Insecticide	Controls insects on corn, cotton, vines, and fruit	R	1	No	0.16 µg/L	—	—	—
Swep (1918-18-9)	SWEP	Herbicide	Controls weeds on rice, corn, peas, and peanuts	N	4	No	0.15 µg/L	—	—	—
2,4,5-T (Trichlorophenoxyacetic acid) (93-76-5)	Weedone	Herbicide	Controls woody plants in industrial areas	C	3	No	0.10 µg/L	70 µg/L	—	—
Tebuthiuron (34014-18-1)	Graslan Spike	Herbicide	Controls vegetative weeds in non-crop and rangeland	R	1	No	0.23 µg/L	500 µg/L	—	—
Terbacil (5902-51-2)	Sinbar	Herbicide	Controls annual and perennial weeds in sugar cane, alfalfa, apples, peaches, citrus, pecans, and mint	R	1	No	1.7 µg/L	0.9 µg/L	—	—
Terbufos (13071-79-9)	Counter	Insecticide	Controls soil insects and nematodes on corn, vegetables, and sorghum	R	1	*	—	0.9 µg/L	—	—
Terbutryn (886-50-0)	Igran Preban	Herbicide	Controls weeds in winter wheat and barley	C	1	No	0.15 µg/L	—	—	—
2,4,5-TP (Trichlorophenol) (95-95-4)	Silvex	Herbicide	Controls weeds and brush in rangeland, sugar cane, and rice	C	3	No	0.10 µg/L	50 µg/L	50 µg/L (5/22/89)	—

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Exhibit E-1 (continued)
National Pesticide Survey Analytes

Analyte (CAS Registry Number)	Common and/or Trade Names	Type	Principal Use	Regulatory Status	NPS Analytical Method	Detected in NPS	NPS Minimum Reporting Limit	Lifetime Health Advisory Level	Maximum Contaminant Level	Risk Specific Dose at 10^{-4} Cancer Risk
Triadimefon (43121-43-3)	Bayleton	Fungicide	Controls mildew and rusts on vegetables, cereals, coffee, and fruit	R	1	No	0.16 µg/L	—	—	—
Tricyclazole (41814-78-2)	Beam Bim Blascide	Fungicide	Controls fungus in seeded rice	N or W	1	No	0.80 µg/L	—	—	—
Trifluralin (1582-09-8)	Treflan	Herbicide	Controls annual grasses, weeds in soy beans, cotton, and vegetables	R	2	No	0.13 µg/L	5 µg/L	—	5 µg/L
Vernolate (1929-77-7)	Vernam	Herbicide	Controls broadleaf and grassy weeds	R	1	No	0.19 µg/L	—	—	—

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Exhibit E-2
Minimum Quantification Limits (MQL)

Analyte	Contract Lab MQL (μg/L)	EPA Lab MQL (μg/L)
METHOD 1		
Alachlor	1.0	1.5
Ametryn	0.26	0.90
Atraton	0.34	0.35
Atrazine	0.24	0.30
Bromacil	2.2	16
Butachlor	1.5	1.8
Butylate	0.60	1.2
Carboxin	1.0	6.0
Chlorpropham	0.70	4.0
Cycloate	0.40	0.80
Diazinon	Qualitative	Qualitative
Dichlorvos	0.24	2.4
Diphenamid	0.43	1.0
Disulfoton	Qualitative	Qualitative
Disulfoton sulfone	Qualitative	Qualitative
Disulfoton sulfoxide	Qualitative	Qualitative
EPTC	0.30	0.60
Ethoprop	0.12	0.30
Fenamiphos	0.30	2.2
Fenarimol	0.40	0.60
Fluridone	1.8	3.8
Hexazinone	0.27	0.60
Merphos	Qualitative	Qualitative
Methyl paraoxon	0.30	12
Metolachlor	1.5	4.4

Exhibit E-2 (continued)
Minimum Quantification Limits (MQL)

Analyte	Contract Lab MQL (µg/L)	EPA Lab MQL (µg/L)
Metribuzin	0.36	0.80
Mevinphos	0.30	2.3
MGK 264	2.1	4.0
Molinate	0.36	0.79
Napropamide	0.50	0.80
Norflurazon	0.36	0.60
Pebulate	0.38	0.80
Prometon	0.29	0.30
Prometryn	0.20	0.80
Pronamide	Qualitative	Qualitative
Propazine	0.20	0.30
Simetryn	0.10	0.90
Simazine	0.75	0.29
Stirofos	0.36	8.0
Tebuthiuron	0.45	0.40
Terbacil	3.5	16
Terbufos	Qualitative	Qualitative
Terbutryn	0.30	0.79
Triademefon	0.32	0.40
Tricyclazole	1.2	8.0
Vernolate	0.37	1.2
METHOD 2		
Aldrin	0.12	0.050
alpha-Chlordane	0.12	0.0050
gamma-Chlordane	0.12	0.010
Chlorneb	1.4	0.16
Chlorobenzilate	Qualitative	Qualitative

Exhibit E-2 (continued)
Minimum Quantification Limits (MQL)

Analyte	Contract Lab MQL (μg/L)	EPA Lab MQL (μg/L)
Chlorothalonil	0.12	0.070
DCPA	0.12	0.015
4,4-DDD	0.25	0.015
4,4-DDE	0.12	0.025
4,4-DDT	0.30	0.18
Dieldrin	0.12	0.10
Endosulfan I	0.12	0.025
Endosulfan II	0.25	0.025
Endosulfan sulfate	0.25	0.040
Endrin	0.25	0.010
Endrin aldehyde	0.25	0.020
Etridiazole	0.25	0.070
alpha-HCH	0.12	0.010
beta-HCH	0.12	0.010
delta-HCH	Qualitative	Qualitative
gamma-HCH	0.085	0.0050
Heptachlor	0.12	0.055
Heptachlor-epoxide	0.12	0.020
Hexachlorobenzene	0.12	0.010
Methoxychlor	0.60	0.41
cis-Permethrin	1.8	1.8
trans-Permethrin	3.9	4.4
Propachlor	1.3	0.55
Trifluralin	0.25	0.015

Exhibit E-2 (continued)
Minimum Quantification Limits (MQL)

Analyte	Contract Lab MQL (μg/L)	EPA Lab MQL (μg/L)
METHOD 3		
Acifluorfen	Qualitative	Qualitative
2,4-DB	2.0	3.2
Bentazon	0.50	2.0
Chloramben	Qualitative	Qualitative
2,4-D	0.50	1.6
Dalapon	Qualitative	Qualitative
DCPA acid metabolites	0.20	0.20
Dicamba	0.20	0.40
3,5-Dichlorobenzoic acid	0.60	0.80
Dichlorprop	0.50	1.0
Dinoseb	2.5	1.0
5-Hydroxy Dicamba	0.20	3.2
4-Nitrophenol	Qualitative	Qualitative
PCP	0.20	0.20
Picloram	1.0	1.6
2,4,5-T	0.20	0.40
2,4,5-TP	0.20	0.40
METHOD 4		
Atrazine dealkylated	4.4	3.1
Barban	3.8	10
Carbofuran phenol	42	18
Cyanazine	4.7	4.9
Diuron	0.63	0.52
Fenamiphos sulfone	57	62
Fenamiphos sulfoxide	9.4	40
Fluometuron	0.95	1.3

Exhibit E-2 (continued)
Minimum Quantification Limits (MQL)

Analyte	Contract Lab MQL (µg/L)	EPA Lab MQL (µg/L)
3-Ketocarbofuran phenol	1.8	2.2
Linuron	0.95	0.56
Metribuzin DA	1.2	0.90
Metribuzin DADK	Qualitative	Qualitative
Metribuzin DK	Qualitative	Qualitative
Neburon	0.60	0.62
Pronamide metabolite	6.2	4.6
Propanil	0.60	0.56
Propham	11	10
Swep	0.30	0.87
METHOD 5		
Aldicarb	1.4	2.6
Aldicarb sulfone	1.2	2.0
Aldicarb sulfoxide	1.7	2.4
Baygon	1.9	3.1
Carbaryl	1.2	1.7
Carbofuran	2.3	3.2
3-Hydroxycarbofuran	2.1	3.4
Methiocarb	2.9	5.0
Methomyl	1.2	1.8
Oxamyl	1.9	2.7
METHOD 6		
ETU	9.0	7.5

Exhibit E-2 (continued)
Minimum Quantification Limits (MQL)

Analyte	Contract Lab MQL (µg/L)	EPA Lab MQL (µg/L)
METHOD 7		
EDB	0.020	0.042
DBCP	0.020	0.027
1,2-Dichloropropane	1.5	7.5
cis-1,3-Dichloropropene	0.020	0.29
trans-1,3-Dichloropropene	0.19	0.36

Analyte	Contract Lab MQL (mg/L)	EPA Lab MQL (mg/L)
METHOD 9		
Nitrate	0.30	0.30

Exhibit E-3
Quality Control Failures

Analyte	Total No. Deleted	No. Laboratory Related	No. Sampling Related
METHOD 1			
Alachlor	112	54	58
Ametryn	134	76	58
Atraton	151	93	58
Atrazine	124	66	58
Bromacil	99	41	58
Butachlor	157	99	58
Butylate	142	84	58
Carboxin	150	92	58
Chlorpropham	125	67	58
Cycloate	119	61	58
Diazinon	92	34	58
Dichlorvos	117	59	58
Diphenamid	96	38	58
Disulfoton	92	34	58
Disulfoton sulfone	92	34	58
Disulfoton sulfoxide	92	34	58
EPTC	110	52	58
Ethoprop	126	68	58
Fenamiphos	122	64	58
Fenarimol	120	62	58
Fluridone	125	67	58
Hexazinone	132	74	58
Merphos	92	34	58
Methyl paraoxon	132	74	58
Metolachlor	135	77	58

Exhibit E-3 (continued)
Quality Control Failures

Analyte	Total No. Deleted	No. Laboratory Related	No. Sampling Related
Metribuzin	102	44	58
Mevinphos	100	42	58
MGK 264	136	78	58
Molinate	136	78	58
Napropamide	136	78	58
Norflurazon	123	65	58
Pebulate	150	92	58
Prometon	96	38	58
Prometryn	92	34	58
Pronamide	92	34	58
Propazine	123	65	58
Simetryn	110	52	58
Simazine	153	95	58
Stirofos	109	51	58
Tebuthiuron	100	42	58
Terbacil	127	69	58
Terbufos	92	34	58
Terbutryn	119	61	58
Triademefon	99	41	58
Tricyclazole	117	59	58
Vernolate	116	58	58
METHOD 2			
Aldrin	82	25	57
alpha-Chlordane	78	21	57
gamma-Chlordane	78	21	57
Chloroneb	76	19	57
Chlorobenzilate	76	19	57

Exhibit E-3 (continued)
Quality Control Failures

Analyte	Total No. Deleted	No. Laboratory Related	No. Sampling Related
Chlorothalnil	119	62	57
DCPA	78	21	57
4,4'-DDD	78	21	57
4,4'-DDE	78	21	57
4,4'-DDT	82	25	57
Dieldrin	76	19	57
Endosulfan I	76	19	57
Endosulfan II	76	19	57
Endosulfan sulfate	78	21	57
Endrin	82	25	57
Endrin aldehyde	76	19	57
Etridiazole	80	23	57
alpha-HCH	84	27	57
beta-HCH	78	21	57
delta-HCH	76	19	57
gamma-HCH	82	25	57
Heptachlor	78	21	57
Heptachlor epoxide	76	19	57
Hexachlorobenzene	80	23	57
Methoxychlor	84	27	57
cis-Permethrin	80	23	57
trans-Permethrin	86	29	57
Propachlor	76	19	57
Trifluralin	82	25	57
METHOD 3			
Acifluorfen	69	11	58
2,4-DB	83	25	58

Exhibit E-3 (continued)
Quality Control Failures

Analyte	Total No. Deleted	No. Laboratory Related	No. Sampling Related
Bentazon	89	31	58
Chloramben	69	11	58
2,4-D	98	40	58
Dalapon	69	11	58
DCPA acid metabolites	71	13	58
Dicamba	87	29	58
3,5-Dichlorbenzoic acid	82	24	58
Dichloroprop	94	36	58
Dinoseb	108	50	58
5-Hydroxy Dicamba	91	33	58
4-Nitrophenol	69	11	58
PCP	120	62	58
Picloram	100	42	58
2,4,5-T	82	24	58
2,4,5-TP	69	11	58
METHOD 4			
Atrazine dealkylated	81	22	59
Barban	66	7	59
Carbofuran phenol	80	21	59
Cyanzine	70	11	59
Diuron	71	12	59
Fenamiphos sulfone	93	34	59
Fenamiphos sulfoxide	68	9	59
Fluometuron	72	13	59
3-Ketocarbofuran phenol	65	6	59
Linuron	79	20	59
Metribuzin DA	102	43	59

Exhibit E-3 (continued)
Quality Control Failures

Analyte	Total No. Deleted	No. Laboratory Related	No. Sampling Related
Metribuzin DADK	65	6	59
Metribuzin DK	65	6	59
Neburon	65	6	59
Pronamide metabolite	65	6	59
Propanil	71	12	59
Propham	73	14	59
Swep	68	9	59
METHOD 5			
Aldicarb	60	0	60
Aldicarb sulfone	61	1	60
Aldicarb sulfoxide	61	1	60
Baygon	60	0	60
Carbaryl	60	0	60
Carbofuran	60	0	60
3-Hydroxycarbofuran	60	0	60
Methiocarb	60	0	60
Methomyl	60	0	60
Oxamyl	60	0	60
METHOD 6			
ETU	79	16	63
METHOD 7			
EDB	67	9	58
DBCP	67	9	58
1,2-Dichloropropane	67	9	58
cis-1,3-Dichloropropene	67	9	58
trans-1,3-Dichloropropene	67	9	58

Exhibit E-3 (continued)
Quality Control Failures

Analyte	Total No. Deleted	No. Laboratory Related	No. Sampling Related
METHOD 9			
Nitrate	58	1	57

Exhibit E-4
Laboratory Control Standards Precision and Accuracy (10 Times MQL)

Analyte	Contract Lab		EPA Lab	
	Average Recovery	% Relative Standard Deviation	Average Recovery	% Relative Standard Deviation
METHOD 1				
Alachlor	97	5.2	92	6.4
Ametryn	96	6.5	90	7.2
Atraton	108	7.4	91	6.2
Atrazine	98	5.3	93	5.9
Bromacil	96	7.2	91	7.1
Butachlor	96	6.1	92	8.0
Butylate	82	10.4	84	8.2
Carboxin	92	11.3	87	9.7
Chlorpropham	98	6.5	94	5.6
Cycloate	94	5.4	91	5.5
Diazinon	64	60.6	48	72.1
Dichlorvos	97	5.3	93	10.0
Diphenamid	96	7.0	94	5.7
Disulfoton	77	25.4	67	37.4
Disulfoton sulfone	92	10.7	79	35.4
Disulfoton sulfoxide	96	9.8	76	17.3
EPTC	92	4.5	89	13.0
Ethoprop	97	5.3	90	7.8
Fenamiphos	91	13.6	87	13.7
Fenarimol	98	7.6	93	6.8
Fluridone	96	9.7	94	10.5
Hexazinone	96	9.8	93	9.3
Merphos	104	32.8	122	15.4
Methyl paraoxon	102	8.8	84	15.5

Exhibit E-4 (continued)
Laboratory Control Standards Precision and Accuracy (10 Times MQL)

Analyte	Contract Lab		EPA Lab	
	Average Recovery	% Relative Standard Deviation	Average Recovery	% Relative Standard Deviation
Metolachlor	97	6.0	93	6.0
Metribuzin	95	5.4	89	6.9
Mevinphos	97	5.4	88	13.9
MGK 264	90	9.4	91	6.0
Molinate	95	5.1	91	5.9
Napropamide	98	8.3	90	9.9
Norflurazon	98	7.8	91	10.1
Pebulate	90	6.2	89	5.8
Prometon	96	5.6	92	6.2
Prometryn	96	5.9	92	6.6
Pronamide	37	92.4	65	68.5
Propazine	97	4.9	93	5.9
Simetryn	96	6.7	90	7.4
Simazine	97	5.8	94	5.8
Stirofos	99	8.0	92	12.5
Tebuthiuron	96	6.6	86	8.1
Terbacil	98	7.1	90	11.5
Terbufos	47	75.0	36	89.5
Terbutryn	96	6.1	92	6.6
Triademefon	98	6.5	93	6.2
Tricyclazole	97	9.9	92	10.5
Vernolate	89	6.4	88	6.4
METHOD 2				
Aldrin	84	12.3	80	11.5
alpha-Chlordane	96	13.7	86	8.4

Exhibit E-4 (continued)
Laboratory Control Standards Precision and Accuracy (10 Times MQL)

Analyte	Contract Lab		EPA Lab	
	Average Recovery	% Relative Standard Deviation	Average Recovery	% Relative Standard Deviation
gamma-Chlordane	100	14.6	86	10.9
Chlorneb	95	9.9	106	12.1
Chlorobenzilate	97	44.7	96	17.3
Chlorothalonil	74	16.1	111	13.8
DCPA	103	14.1	90	6.3
4,4-DDD	99	20.2	99	18.5
4,4-DDE	97	19.6	85	12.4
4,4-DDT	95	21.0	103	20.4
Dieldrin	94	13.3	98	15.4
Endosulfan I	99	14.1	97	12.2
Endosulfan II	93	15.3	98	19.1
Endosulfan sulfate	97	19.1	86	19.5
Endrin	97	16.4	99	14.1
Endrin aldehyde	93	16.6	94	17.0
Etridiazole	102	12.9	106	20.0
alpha-HCH	95	10.5	97	11.8
beta-HCH	100	13.1	88	9.2
delta-HCH	96	27.6	94	10.5
gamma-HCH	112	10.4	97	9.5
Heptachlor	97	13.1	77	9.9
Heptachlor-epoxide	93	11.1	97	11.4
Hexachlorobenzene	91	25.2	79	18.4
Methoxychlor	108	22.4	89	17.0
cis-Permethrin	109	24.8	99	18.4
trans-Permethrin	106	22.9	89	15.8

Exhibit E-4 (continued)
Laboratory Control Standards Precision and Accuracy (10 Times MQL)

Analyte	Contract Lab		EPA Lab	
	Average Recovery	% Relative Standard Deviation	Average Recovery	% Relative Standard Deviation
Propachlor	102	8.4	100	10.7
Trifluralin	103	16.2	81	15.7
METHOD 3				
Acifluorfen	69	41.3	51	24.5
2,4-DB	98	10.7	90	4.1
Bentazon	100	8.2	92	3.8
Chloramben	10	119.3	53	30.3
2,4-D	97	9.1	93	4.0
Dalapon	105	19.0	49	29.1
DCPA acid metabolites	94	8.8	93	4.5
Dicamba	95	9.3	89	7.2
3,5-Dichlorobenzoic acid	94	9.7	73	9.3
Dichlorprop	99	10.1	91	3.9
Dinoseb	81	24.4	40	30.9
5-Hydroxy Dicamba	87	13.9	94	3.4
4-Nitrophenol	96	19.1	75	15.1
PCP	86	22.7	73	7.5
Picloram	84	18.7	87	7.9
2,4,5-T	96	8.6	99	8.5
2,4,5-TP	98	8.0	89	6.0
METHOD 4				
Atrazine dealkylated	85	11.0	94	5.6
Barban	91	7.5	101	2.9
Carbofuran phenol	93	11.5	100	5.2
Cyanazine	94	7.0	100	3.8

Exhibit E-4 (continued)
Laboratory Control Standards Precision and Accuracy (10 Times MQL)

Analyte	Contract Lab		EPA Lab	
	Average Recovery	% Relative Standard Deviation	Average Recovery	% Relative Standard Deviation
Diuron	92	8.0	100	3.6
Fenamiphos sulfone	94	13.4	102	3.8
Fenamiphos sulfoxide	93	12.2	100	4.3
Fluometuron	89	7.4	101	2.6
3-Ketocarbofuran phenol	90	6.2	98	5.7
Linuron	91	7.5	102	4.1
Metribuzin DA	83	11.9	97	6.3
Metribuzin DADK	20	13.9	.	.
Metribuzin DK	34	14.7	.	.
Neburon	88	7.8	99	1.9
Pronamide metabolite	97	7.9	100	4.2
Propanil	93	8.7	100	3.5
Propham	92	6.7	99	2.3
Swep	94	10.3	100	3.6
METHOD 6				
ETU	91	5.9	96	9.3

Exhibit E-5
Laboratory Control Standards vs. Spiked Field Sample Results (Spiking Level 10 Times MQL)

Analyte	Spiked Samples		Lab Control Standard	
	Average Recovery	% Relative Standard Deviation	Average Recovery	% Relative Standard Deviation
METHOD 1				
Alachlor	98	3.6	97	5.2
Ametryn	98	9.7	96	6.5
Atraton	110	12.1	108	7.4
Atrazine	100	4.2	98	5.3
Bromacil	98	5.9	96	7.2
Butachlor	97	10.0	96	6.1
Butylate	88	6.0	82	10.4
Carboxin	89	7.6	92	11.3
Chlorpropham	99	5.6	98	6.5
Cycloate	94	5.5	94	5.4
Diazinon	87	14.3	64	60.6
Dichlorvos	97	5.9	97	5.3
Diphenamid	99	5.6	96	7.0
Disulfoton	83	13.1	77	25.4
Disulfoton sulfone	88	10.5	92	10.7
Disulfoton sulfoxide	91	10.6	96	9.8
EPTC	94	3.7	92	4.5
Ethoprop	99	2.9	97	5.3
Fenamiphos	95	16.2	91	13.6
Fenarimol	101	10.4	98	7.6
Fluridone	97	11.7	96	9.7
Hexazinone	97	10.6	96	9.8
Merphos	80	27.2	104	32.8
Methyl paraoxon	109	6.8	102	8.8

Exhibit E-5 (continued)
Laboratory Control Standards vs. Spiked Field Sample Results
(Spiking Level 10 Times MQL)

Analyte	Spiked Samples		Lab Control Standard	
	Average Recovery	% Relative Standard Deviation	Average Recovery	% Relative Standard Deviation
Metolachlor	98	9.5	97	6.0
Metribuzin	95	6.2	95	5.4
Mevinphos	98	6.2	97	5.4
MGK 264	88	11.9	90	9.4
Molinate	96	3.8	95	5.1
Napropamide	101	10.2	98	8.3
Norflurazon	99	9.2	98	7.8
Pebulate	91	6.0	90	6.2
Prometon	97	7.2	96	5.6
Prometryn	96	6.9	96	5.9
Pronamide	27	73.7	37	92.4
Propazine	98	6.0	97	4.9
Simetryn	96	8.3	96	6.7
Simazine	97	8.1	97	5.8
Stirofos	104	5.7	99	8.0
Tebuthiuron	95	7.0	96	6.6
Terbacil	101	9.1	98	7.1
Terbufos	45	74.9	47	75.0
Terbutryn	98	4.0	96	6.1
Triademefon	99	8.5	98	6.5
Tricyclazole	104	10.7	97	9.9
Vernolate	90	6.1	89	6.4
METHOD 2				
Aldrin	80	12.0	84	12.3
alpha-Chlordane	92	11.2	96	13.7

Exhibit E-5 (continued)
Laboratory Control Standards vs. Spiked Field Sample Results (Spiking Level 10 Times MQL)

Analyte	Spiked Samples		Lab Control Standard	
	Average Recovery	% Relative Standard Deviation	Average Recovery	% Relative Standard Deviation
gamma-Chlordane	97	11.1	100	14.6
Chlorneb	94	11.6	95	9.9
Chlorobenzilate	108	18.1	97	44.7
Chlorothalonil	75	15.7	74	16.1
DCPA	109	10.0	103	14.1
4,4-DDD	92	17.7	99	20.2
4,4-DDE	89	16.1	97	19.6
4,4-DDT	92	21.1	95	21.0
Dieldrin	91	12.3	94	13.3
Endosulfan I	96	13.5	99	14.1
Endosulfan II	90	18.0	93	15.3
Endosulfan sulfate	94	16.9	97	19.1
Endrin	94	17.2	97	16.4
Endrin aldehyde	92	15.0	93	16.6
Etridiazole	105	13.4	102	12.9
alpha-HCH	92	8.3	95	10.5
beta-HCH	100	10.7	100	13.1
delta-HCH	95	11.4	95	27.6
gamma-HCH	111	12.2	112	10.4
Heptachlor	96	8.2	97	13.1
Heptachlor-epoxide	91	11.0	93	11.1
Hexachlorobenzene	96	9.2	91	25.2
Methoxychlor	118	30.2	108	22.4
cis-Permethrin	103	25.9	109	24.8
trans-Permethrin	96	27.4	106	22.9

Exhibit E-5 (continued)
Laboratory Control Standards vs. Spiked Field Sample Results (Spiking Level 10 Times MQL)

Analyte	Spiked Samples		Lab Control Standard	
	Average Recovery	% Relative Standard Deviation	Average Recovery	% Relative Standard Deviation
Propachlor	100	9.4	102	8.4
Trifluralin	108	16.1	103	16.2
METHOD 3				
Acifluorfen	76	50.1	69	41.3
2,4-DB	100	12.9	98	10.7
Bentazon	101	10.1	100	8.2
Chloramben	11	120.1	10	119.3
2,4-D	98	12.9	97	9.1
Dalapon	100	19.2	105	19.0
DCPA acid metabolites	97	8.8	94	8.8
Dicamba	98	6.4	95	9.3
3,5-Dichlorobenzoic acid	95	10.5	94	9.7
Dichlorprop	98	10.3	99	10.1
Dinoseb	84	25.3	81	24.4
5-Hydroxy Dicamba	90	10.9	87	13.9
4-Nitrophenol	89	36.3	96	19.1
PCP	81	34.4	86	22.7
Picloram	82	15.9	84	18.7
2,4,5-T	99	8.4	96	8.6
2,4,5-TP	100	7.9	98	8.0
METHOD 4				
Atrazine dealkylated	83	7.5	86	11.0
Barban	91	8.8	91	7.5
Carbofuran phenol	95	10.9	93	11.5
Cyanazine	94	6.5	94	7.0

Exhibit E-5 (continued)
Laboratory Control Standards vs. Spiked Field Sample Results
(Spiking Level 10 Times MQL)

Analyte	Spiked Samples		Lab Control Standard	
	Average Recovery	% Relative Standard Deviation	Average Recovery	% Relative Standard Deviation
Diuron	94	5.2	32	8.0
Fenamiphos sulfone	94	6.8	94	13.4
Fenamiphos sulfoxide	95	7.8	93	12.2
Fluometuron	91	7.2	89	7.4
3-Ketocarbofuran phenol	89	5.9	90	6.2
Linuron	91	7.1	91	7.5
Metribuzin DA	79	10.6	83	11.9
Metribuzin DADK	17	.	20	13.9
Metribuzin DK	.	.	34	14.7
Neburon	89	7.5	88	7.8
Pronamide metabolite	98	3.5	97	7.9
Propanil	95	3.9	93	8.7
Propham	93	5.4	92	6.7
Swep	95	7.4	94	10.3
METHOD 5				
Aldicarb	100	7.0	NA	NA
Aldicarb sulfone	101	5.3	NA	NA
Aldicarb sufoxide	100	6.9	NA	NA
Baygon	99	4.3	NA	NA
Carbaryl	97	5.6	NA	NA
Carbofuran	99	4.0	NA	NA
3-Hydroxycarbofuran	99	4.0	NA	NA
Methiocarb	94	4.7	NA	NA
Methomyl	102	4.8	NA	NA
Oxamyl	98	4.3	NA	NA

Exhibit E-5 (continued)
Laboratory Control Standards vs. Spiked Field Sample Results
(Spiking Level 10 Times MQL)

	Spiked Samples		Lab Control Standard	
Analyte	Average Recovery	% Relative Standard Deviation	Average Recovery	% Relative Standard Deviation
METHOD 6				
ETU	93	7.4	91	5.9
METHOD 7				
EDB	97	7.7	NA	NA
DBCP	95	10.1	NA	NA
1,2-Dichloropropane	96	10.5	NA	NA
cis-1,3-Dichloropropene	97	8.8	NA	NA
trans-1,3-Dichloropropene	102	10.5	NA	NA
METHOD 9				
Nitrate	103	5.9	NA	NA

Exhibit-6
False Negative Rates

Analyte	No. of Duplicates	No. of False Negatives	% of False Negatives
METHOD 1			
Alachlor	111	0	<0.89
Ametryn	108	0	<0.92
Atraton	105	0	<0.94
Atrazine	108	1	0.93
Bromacil	111	0	<0.89
Butachlor	103	0	<0.96
Butylate	108	0	<0.92
Carboxin	97	0	<1.0
Chlorpropham	112	0	<0.88
Cycloate	110	0	<0.90
Diazinon	112	0	<0.88
Dichlorvos	101	0	<0.98
Diphenamid	112	0	<0.88
Disulfoton	112	0	<0.88
Disulfoton sulfone	112	0	<0.88
Disulfoton sulfoxide	112	0	<0.88
EPTC	100	0	<0.99
Ethoprop	110	0	<0.90
Fenamiphos	100	0	<0.99
Fenarimol	109	0	<0.91
Fluridone	97	0	<1.0
Hexazinone	100	0	<0.99
Merphos	112	0	<0.88
Methyl paraoxon	107	0	<0.93
Metolachlor	105	0	<0.94
Metribuzin	110	0	<0.90

Exhibit-6 (continued)
False Negative Rates

Analyte	No. of Duplicates	No. of False Negatives	% of False Negatives
Mevinphos	112	0	<0.88
MGK 264	111	0	<0.89
Molinate	104	0	<0.95
Napropamide	90	0	<1.1
Norflurazon	93	0	<1.1
Pebulate	108	0	<0.92
Prometon	109	0	<0.91
Prometryn	108	0	<0.92
Pronamide	112	0	<0.88
Propazine	107	0	<0.93
Simetryn	107	0	<0.93
Simazine	105	0	<0.94
Stirofos	102	0	<0.97
Tebuthiuron	103	0	<0.96
Terbacil	109	0	<0.91
Terbufos	112	0	<0.88
Terbutryn	108	0	<0.92
Triademefon	111	0	<0.89
Tricyclazole	109	0	<0.91
Vernolate	112	0	<0.88
METHOD 2			
Aldrin	119	0	<0.83
alpha-Chlordane	118	0	<0.84
gamma-Chlordane	120	0	<0.83
Chlorneb	117	0	<0.85
Chlorobenzilate	120	0	<0.83
Chlorothalonil	113	0	<0.88

Exhibit-6 (continued)
False Negative Rates

Analyte	No. of Duplicates	No. of False Negatives	% of False Negatives
DCPA	120	0	<0.83
4,4-DDD	120	0	<0.83
4,4-DDE	120	0	<0.83
4,4-DDT	118	0	<0.84
Dieldrin	118	0	<0.84
Endosulfan I	120	0	<0.83
Endosulfan II	120	0	<0.83
Endosulfan sulfate	116	0	<0.85
Endrin	120	0	<0.83
Endrin aldehyde	118	0	<0.84
Etridiazole	113	0	<0.88
alpha-HCH	118	0	<0.84
beta-HCH	120	0	<0.83
delta-HCH	120	0	<0.83
gamma-HCH	120	0	<0.83
Heptachlor	120	0	<0.83
Heptachlor-epoxide	120	0	<0.83
Hexachlorobenzene	119	0	<0.83
Methoxychlor	120	0	<0.83
cis-Permethrin	117	0	<0.85
trans-Permethrin	119	0	<0.83
Propachlor	120	0	<0.83
Trifluralin	117	0	<0.85
METHOD 3			
Acifluorfen	133	0	<0.75
2,4-DB	132	0	<0.75
Bentazon	132	0	<0.75

Exhibit-6 (continued)
False Negative Rates

Analyte	No. of Duplicates	No. of False Negatives	% of False Negatives
Chloramben	133	0	<0.75
2,4-D	125	0	<0.79
Dalapon	133	0	<0.75
DCPA acid metabolites	133	1	0.75
Dicamba	128	0	<0.78
3,5-Dichlorobenzoic acid	132	0	<0.75
Dichlorprop	132	0	<0.75
Dinoseb	127	0	<0.78
5-Hydroxy Dicamba	133	0	<0.75
4-Nitrophenol	132	0	<0.75
PCP	128	0	<0.78
Picloram	121	0	<0.82
2,4,5-T	128	0	<0.78
2,4,5-TP	133	0	<0.75
METHOD 4			
Atrazine dealkylated	114	0	<0.87
Barban	130	0	<0.76
Carbofuran phenol	122	0	<0.81
Cyanazine	131	0	<0.76
Diuron	129	0	<0.77
Fenamiphos sulfone	123	0	<0.81
Fenamiphos sulfoxide	129	0	<0.77
Fluometuron	120	0	<0.83
3-Ketocarbofuran phenol	125	0	<0.79
Linuron	126	0	<0.79
Metribuzin DA	121	0	<0.82
Metribuzin DADK	134	0	<0.74

Exhibit-6 (continued)
False Negative Rates

Analyte	No. of Duplicates	No. of False Negatives	% of False Negatives
Metribuzin DK	134	0	<0.74
Neburon	129	0	<0.77
Pronamide metabolite	130	0	<0.76
Propanil	127	0	<0.78
Propham	132	0	<0.75
Swep	129	0	<0.77
METHOD 5			
Aldicarb	88	0	<1.1
Aldicarb sulfone	88	0	<1.1
Aldicarb sulfoxide	87	0	<1.1
Baygon	88	0	<1.1
Carbaryl	88	0	<1.1
Carbofuran	88	0	<1.1
3-Hydroxycarbofuran	88	0	<1.1
Methiocarb	88	0	<1.1
Methomyl	88	0	<1.1
Oxamyl	87	0	<1.1
METHOD 6			
ETU	126	0	<0.79
METHOD 7			
EDB	82	0	<1.2
DBCP	82	0	<1.2
1,2-Dichloropropane	82	0	<1.2
cis-1,3-Dichloropropene	82	0	<1.2
trans-1,3-Dichloropropene	82	0	<1.2
METHOD 9			
Nitrate	119	0	<0.83